AL/HR-TP-1996-0001

USER MANUAL: THE GENERIC ASSIGNMENT TEST AND EVALUATION SIMULATOR (GATES)

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February 1996

Interim Technical Paper for Period February 1993 - March 1995

ARMSTRONG LABORATORY

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This report has been reviewed and is approved for publication.

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	February 1996	Interim - February 1993-March 1995

4. TITLE AND SUBTITLE

User Manual: The Generic Assignment Test and Evaluation Simulator (GATES)

5. FUNDING NUMBERS

C - F49650-92-D5005
PE - 62205F
PR - 7719
TA - 20
WU - 26

6. AUTHOR(S)

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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Systems Research and Applications Corporation
1777 Northeast Loop 410, Suite 510
San Antonio, TX 78217

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Armstrong Laboaratory
Human Resources Directorate
Manpower and Personnel Research Division
7909 Lindbergh Drive
Brooks AFB, TX 78235-5352

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

AL/HR-TP-1996-0001

11. SUPPLEMENTARY NOTES

Armstrong Laboratory Technical Monitor: Melody M. Darby (210) 536-2257

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The United States Air Force Generic Assignment Test and Evaluation Simulator (GATES) project developed a research tool hosted on a personal computer for addressing personnel selection and classification (S&C) research issues. GATES provides computer simulation capability for evaluating the potential benefits of alternative S&C system designs and assignment algorithm within that system to assign sets of people to jobs. Either existing data bases or generated data sets can be processed. The researcher may then quantify the effectiveness and efficiency of these assignments through evaluation of specificied measures of merit. Results yield comparisons of the effects of various assignment system designs, selection measures, and classification algorithms. GATES was designed to be readily adapted to the policies and data of any of the Military Services. This report begins with a definition of S&C, a presentation of current S&C procedures in the Military Services, and a motivation for the development of GATES. The user manual follows, providing information on software and hardware requirements, installation, support source files, and GATES functions and assignment algorithms. The report concludes with a tutorial which demonstrates the logical order that would be followed in using GATES to design, implement, and analyze a research study.

14. SUBJECT TERMS		15. NUMBER OF PAGES
Job assignments Person-job match Personnel classification	Personnel selection	74
		16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

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PREFACE

The Generic Assignment Test and Evaluation Simulator (GATES) project was accomplished under Work Unit 77192026, Economic and Demographic Force Structure Analysis Technology Development. Software design support was provided by Systems Research and Applications (SRA) Corporation under contract F49650-92-D5005, Delivery Order 5005. Dr. Robert C. Rue was the project manager for the contract team. This report was prepared by Armstrong Laboratory scientists, principally Melody M. Darby, using contract deliverables from SRA Corp. as well as other relevant materials on enlisted assignments, including recent Air Force research publications on personnel classification.

The authors wish to thank Dr. William E. Alley for his theoretical guidance and his contributions to the conceptualization of the form that GATES needed to take. The authors also wish to thank Dr. Patrick C. Kyllonen for his unflagging and enthusiastic support of the GATES project and his hard work into the underpinnings of classification research. His contributions to this project are gratefully acknowledged. Lastly, the authors wish to acknowledge Sharon McDonald for assistance in preparation of the manuscript.

I. INTRODUCTION

The United States Air Force Generic Assignment Test and Evaluation Simulator (GATES) project developed a research tool for addressing selection and classification (S&C) research issues. Existing data bases along with computer simulation capability are combined to create a test bed for evaluating the potential benefits of alternative S&C system designs and assignment methodologies. GATES allows a user to design a S&C system and apply a specified assignment algorithm within that system to assign sets of people to jobs. The user may then quantify the effectiveness and efficiency of these assignments through evaluation of specified measures of merit (MOM). Results from this research will yield accurate comparisons of the effects of various assignment system designs, selection measures, and classification algorithms and, ultimately, improved assignment methodologies. GATES accepts personnel and job data that have been generated as well as extracts from historical files. GATES permits operational assignments to be quantitatively evaluated by research and management personnel. GATES provides the capability to evaluate the classification effects of recruiting personnel with different mental and physical characteristics as well as a capability to evaluate new measurement tests of those characteristics. GATES can be adapted to the policies and data of any of the Military Services.

This report includes a definition of selection and classification, a presentation of the current S&C procedures in the Military Services, and a motivation for the development of GATES. The user manual follows these introductory remarks and includes information on software and hardware requirements, installation information, support source files, and a description of GATES' Windows dialog boxes. Presentation of GATES is in the logical order that would be followed in the design, implementation, and analysis of a research study. This manual includes a tutorial of the application of GATES to address a current research topic.

Background on Selection and Classification

The Military Services are highly dependent on effective personnel S&C systems. The military mission, to protect and defend the interests of the United States, is accomplished by creating a defense organization consisting of hundreds of thousands of well qualified, trained and expert personnel. These forces must be ready to meet a critical defense need, however unexpected. The product of this military 'industry' is the work force itself. More than any other industry, public or private, the military historically has and must continue to place a high priority on effective S&C systems development.

A S&C system can be conceptualized as a supply/demand equation. The supply side is a population of applicants, potential recruits. The demand side is a population of jobs to be filled from the applicant population. Selection is that part of the system which operates on the supply side of the equation, classification applies to the demand side. Selection occurs when an organization chooses to accept or reject an applicant for

eventual assignment to a job. Classification is much more complicated. Once an applicant has been selected, he or she must then be assigned to a particular job. The classification process really represents the goals of an organization stated within the context of organization constraints. Organizational policy, as a complex interacting system of goals and constraints, drives the assigning of a particular recruit to a particular job (Ward, 1977). The actual numbers of jobs (current and forecast) and the numbers and qualifications of applicants (current and forecast) are also key parameters in determining actual assignments.

The active duty military service of the future will be smaller, with proportionally greater numbers of generalist positions that involve working with technologically sophisticated systems. Anticipated changes suggest that new job analyses need to be accomplished to better identify the cognitive demands of technical jobs. Also, selection measures may need to measure cognitive flexibility, or the capability to work effectively on diverse activities, and the ability to work autonomously and, at the same time, as a member of a team. All this places a need on S&C systems to be more flexible and responsive to change. Anticipated changes in the work force or the constraints on classification systems, along with changing job structures and requirements and the development of new measures of ability, will affect future research needs.

Current Selection and Classification Procedures in the Military Services

Selection is very similar across the Services. Figure 1 presents a schematic of the activities, measurements, and decision points that make up each of the Air Force, Army, Navy, and Marine Corps systems (Russell, Knapp, & Campbell, 1992). The recruiter interviews each applicant and conducts all preliminary testing designed to identify and remove those applicants not suited for the service. Such screening includes a determination of the applicant's citizenship status, education level, moral character (e.g., drug use, criminal record) and general physical condition. Also administered is a shortened version of the Armed Forces Qualifying Test (AFQT), the Enlistment Screening Test (EST), designed to determine if the applicant is likely to qualify for the service.

Next the applicant moves on to the Military Entrance Processing Station (MEPS) or a Mobile Examining Team (MET). There the potential recruit is administered the Armed Services Vocational Aptitude Battery (ASVAB). MET sites are smaller, more accessible ASVAB testing stations while the MEPS are larger and are equipped to accomplish the necessary physical examinations for accession. At this point all the Services apply a screening cut score on the AFQT which the applicant must meet or exceed to satisfy mental ability requirements. The Air Force, Navy, and Marine Corps all use the 31st percentile as a cut score. The Army uses the 26th percentile as a cut score. Operationally, the recruiting headquarters in each of the Services can adjust the cut score up from the minimum set by management. All applicants eventually arrive at the MEPS

where they must undergo a physical examination, psychiatric evaluation, HIV testing and, in the case of the Air Force, a strength test. The results of the physical examination and strength testing are summarized into the code, PULHES-X, as measures of Physical stamina, Upper extremity condition, Lower extremity condition, Hearing and Eye acuity, psychiatric profile (S), and the X-factor strength test.

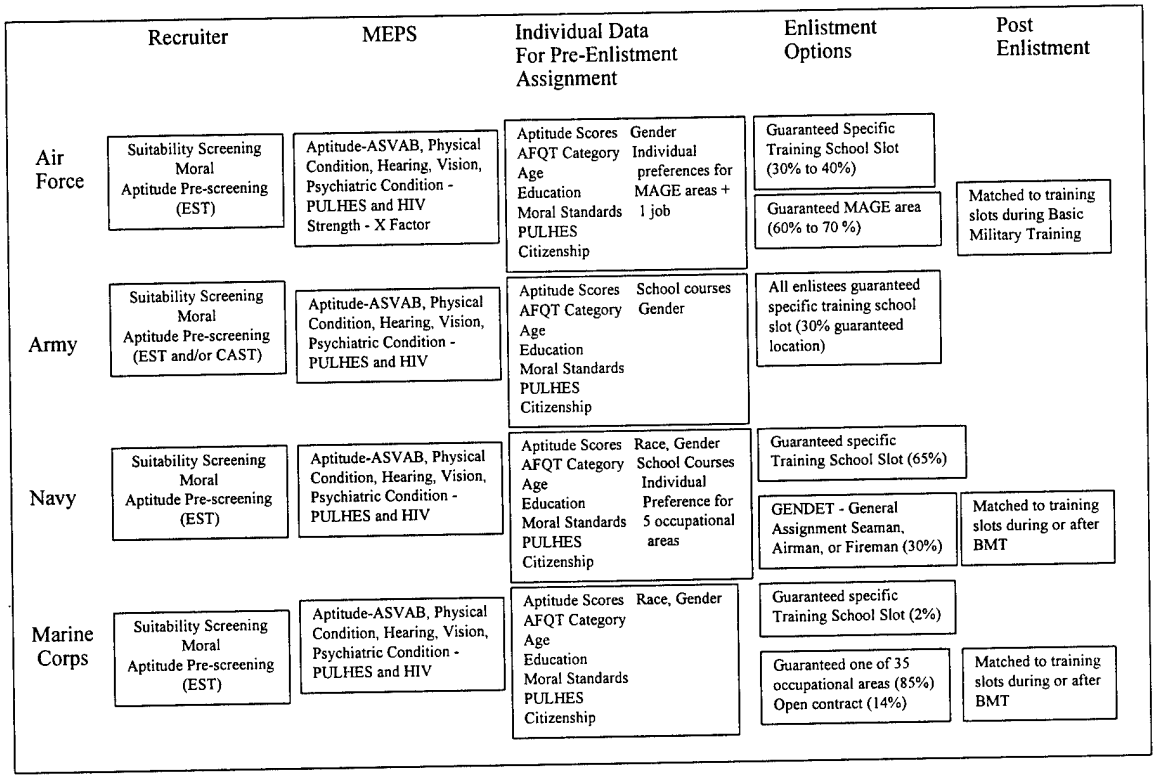


Figure 1. The Military Enlistment and Assignment Process (Russell, Knapp, & Campbell, 1992).

At the MEPS, subsequent to those screening activities pertinent to selection, all the services address the issue of classification into an occupational area or a specialty assignment. A career counselor assembles an applicant's records, aptitude scores, medical history, education, and job/location preferences (Alley, 1978). The counselor and the applicant together view the current and forecast specialties available to the applicant for consideration for which the applicant qualifies. At this point, the applicant makes the final decision to enlist with the guidance of his counselor. Specialty technical training school availability schedules or 'job banks' are maintained on computer software within the greater context of a management information system (MIS). This MIS tracks the processing of enlistees, prepares orders, provides links between the recruiter, the Recruiting Service command, and personnel, as well as provides up to the minute information on technical school class schedules and specialty availability. The actual method employed to match an enlistee to a job is contained within the enlistment MIS as the classification component of the system.

All the Services place similar emphasis on aptitude scores as a means of matching an applicant to a job. Each Service has its own scheme of composites and cut score minimums that are various combinations of ASVAB subtest scores. The ASVAB contains 10 subtests which measure different ability areas, e.g., verbal, math, mechanical knowledge. Composites are formed from the subtests which correspond to occupational areas, e.g., the Air Force Mechanical, Administrative, General, and Electronic (MAGE) occupational areas. Eligibility for and match to an occupation are determined on the basis of values of composites and cut score minimums. The Services are different in the particular way the composites are used to match an individual to a job and the use of additional variables in the matching process. These differences are manifest in the classification component of the enlistment MIS and can vary markedly as a reflection of current organizational policy toward the relative importance of person-job fit (maximizing performance), job fill rates, and job priorities.

All the Services employ a two-tiered classification process with the exception of the Army. The first tier or stage is characterized by a sequential classification process that assigns enlistees to an occupational area or directly to a specific occupation (specialty). The second stage of classification typically occurs at basic training and is a batch process. All those who received an occupational area assignment at the first stage will receive an assignment to a specific specialty at the second stage. Sequential processes (algorithms) assign individuals separately one at a time while batch algorithms assign groups of enlistees concurrently to a group of jobs. Sequential methods employ a "shadow" population resembling the one to which the enlistee actually belongs for the purpose of comparing the individual against other like enlistees when competing for a job assignment. In the batch mode recruits are compared directly to one another. The Army assigns all enlistees to specific jobs at the MEPS.

In summary, there are major differences in classification across the Services. The Services use different composites and cut scores, different variables (i.e., Air Force strength measure), the Army uses a single-tier system, and the classification algorithms as a reflection of organizational policy differ.

What Is GATES?

The S&C military research community is challenged to demonstrate a difference between the quality of assignments actually made and potential improvements in assignment for competing assignment strategies, criterion/predictor measures, occupational specialty clusters, and classification algorithms. Toward this goal GATES was developed at USAF Armstrong Laboratory under contract with Systems Research and Applications (SRA) Corporation. GATES is a S&C research tool hosted on a personal computer which acts as a testbed for verifying and validating new selection and classification measures. GATES is Windows-based and commonly interfaced so as to be user friendly. Although GATES was developed by the Air Force, it is a joint service research conceptualization and is designed for application by the Army, Navy, and

Marine Corps as well (Russell, Knapp, & Campbell, 1992; Campbell & Russell, 1994; Campbell, Russell, & Knapp, 1994). GATES supports the ongoing Department of Defense (DoD) policy to coordinate the research efforts of all its laboratories. GATES was designed to be adapted to data and policies of the other Services. In this role, it provides a core for a joint Service selection and classification test bed.

In order to design an S&C research study, the researcher must first articulate the goals of the S&C system under study. Goals might include: 1) maximize predicted job performance across jobs, 2) insure individuals meet minimum qualification requirements of jobs, 3) maximize job preference match, 4) fit individual aptitude to job complexity, 5) minimize training costs, 6) minimize casual time, or 7) maximize job or training class seat fill rate. Next, goals must be translated into mathematical expressions that quantify the classification utility of a resulting assignment of personnel to jobs. After system goals have been stated, the system constraints must be determined. Constraints are a reflection of organizational policy and operational concerns and as such place limits on the ability of classification systems to accomplish their goals. Once system goals and constraints have been determined and quantitatively expressed, aspects of competing classification systems designed to accomplish those goals within specified constraints can be determined.

GATES facilitates the design and testing of a S&C system. The researcher defines, executes, reports, and revises the design of a S&C research study all within the framework of GATES, thus reducing processing time and necessary processing skills and software. GATES has been configured so as to simplify the comparison of a S&C system performance to that of competing designs. A designed study as well as reports and results may be saved for input or comparison to later studies.

As shown in Figure 2, design features for the GATES Project include: 1) definition of personnel, job, and qualification data, 2) choice of single or two-tiered assignment strategy with specification of proportions to be assigned directly into specialties or as occupational area assignments, 3) a selection of classification algorithms, and 4) specification of output measures of utility, reports, and data files (Darby & Grobman, 1994). GATES can analyze applicant/recruit data that have been generated as well as extracts of actual assignments from historical files. Job data can also be generated or provided from historical extracts. Personnel, job, and qualification information can all be manipulated so as to be representative of any of the Services' standards or data on new/experimental variables can be input.

GATES has the capability to assign a personnel, job and qualification data set as a two-tiered assignment strategy, similar to the Air Force's process, or as a single-tiered strategy, as in the Army's. GATES allows the user to select the classification algorithm or algorithms used to implement the chosen assignment strategy, where one algorithm is required for each tier in the design. Within the two-tier/single-tier framework a menu of sequential and batch classification algorithms are offered.

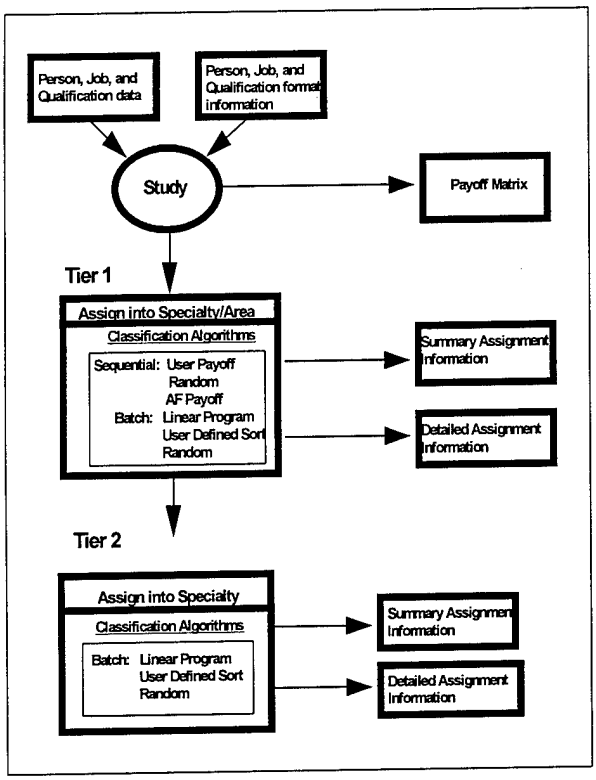


Figure 2. Design Features for the GATES Project

Outputs from GATES will include many measures of merit (MOM) or measures of S&C utility. Typically MOMs are measures related to performance, effectiveness of fit, efficiency of fill, potential productivity of the enlistee in the specialty, training cost, casual time, or job satisfaction. The user can define additional MOMs to evaluate assignments that result from applying the strategy and algorithms. Results are summarized in two report formats, the detailed and summary assignment information reports. A listing of all person-job assignments including individual payoffs, jobs unfilled, and personnel unassigned is provided as the detailed assignment report. The summary assignment report provides statistics on the assignment, payoff or objective functions, and user defined MOM's as well as the expected value of a random assignment. GATES has the capability to generate a full payoff matrix of all personnel and jobs and make the information available as an output data file.

Overview of the User Manual

The next five sections comprise a user manual which contains detailed descriptions of the procedures that are necessary for applying GATES to a research topic. Presentation of the features of GATES will exploit Windows conventions and terminology. The manual begins with an outline of the sequence of procedural steps required to set up a S&C research study (Section II). Section II includes procedures for creating and saving a study; structuring and manipulating personnel, job, and qualification files; editing format files and selecting study settings options; assessing actual assignments from historical files; and creating and using generated data. Study settings allow users to manipulate parameters such as quality, minority or gender goals/caps, file overwrite warnings, casual time limits, random number generator seeds, and sequencing variables.

The next section defines the single/two-tier classification strategy options available in GATES (Section III). A detailed description of the various classification algorithms provided in GATES follows classification strategies. A discussion of the theoretical considerations, definitions, and procedures to quantify system goals as payoff/objective functions invoked by classification algorithms for affecting assignments

is included. GATES' capabilities and procedures for the representation of organizational constraints on system goals are presented in this section.

Section IV discusses MOMs, how they are used to describe an assignment, how they are defined, and the way in which they can be created and edited by the user. Section IV also contains a discussion of the statistics available in GATES on MOMs and the output report formats including the "detailed" and "summary" files. Section V presents a tutorial to demonstrate use of GATES. Section VI concludes with summary remarks.

II. DESIGNING A STUDY WITH GATES

Design aspects covered in this section include creating and saving a study, selecting source files, editing format files, settings, assessing historical assignments, and working with generated data. After installation has been accomplished, a GATES application icon will appear in Program Manager. Opening the GATES application icon will display the GATES menu bar. The menu bar includes Study, Sources Files, View, Strategy, Run, and Help menus.

Installation

GATES requires an IBM PC compatible (80386 processor or higher) using Microsoft Windows 3.1 or later. A mouse and at least four MB of memory is highly recommended. The software requires at least two MB of disk space plus room for the source files. To install GATES, start Windows (type WIN at the DOS prompt) and insert the GATES floppy in the disk drive. From the Program Manager, select Run from the File menu and type a:\setup (b:\setup if your floppy is in the B: drive). Click the OK button with the mouse (or press the <enter< key).

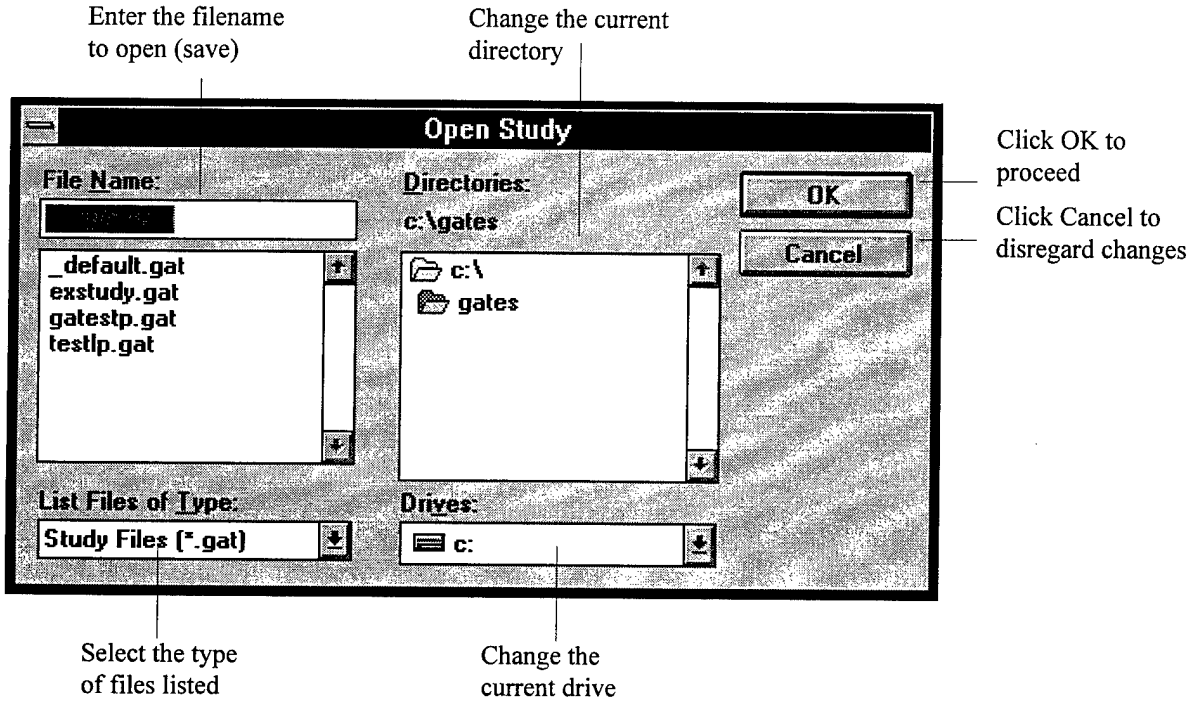
After initializing, the Setup program prompts for the destination directory to contain the GATES software. To select the default (C:\GATES), press the <enter< key. Setup will create a folder and several icons in the Program Manager. To run GATES, double - click on the GATES icon. The GATES Help icon displays the help window without having to execute GATES first. The Wonder spreadsheet icon will execute a simple spreadsheet to view or edit, with conveniently displayed field names, the source files and output from the GATES software. Note that if you have another spreadsheet such as Lotus-1-2-3, Microsoft Excel, or Borland's Quattro Pro, it is recommended to use these instead of Wonder.

Creating and Saving Studies

The Study menu allows the user to open or save GATES study files. Study files contain the specifications and selections for source files, settings, strategy, classification algorithm, algorithm parameters, payoff/objective functions, and MOMs. When a study is opened, the specifications and selections are set to the values in the opened study file.

To Open a Study

1. Click Open from the Study menu.
2. Specify the desired drive and directory.
3. Type the study filename to be retrieved in the File Name text box.
4. Click the OK button.



To Save or Rename a Study

1. Click Save (or Save As) from the Study menu.
2. Specify the desired drive and directory.
3. Type the new filename in the File Name text box.
4. Click the OK button.

Source Files

The data available to GATES are contained in three source files: (a) personnel files, (b) job files, and (c) qualification files. These are stored as comma delimited ASCII files. A variety of spreadsheet and database products will handle these files. GATES comes with a limited capability spreadsheet, Wonder. Wonder uses the comma delimited ASCII format as a default so no importing or exporting is required. Open and Save the file as normal with the File-Open and File-Save menu options. Wonder will display the Field Names as the column headings if the default extensions are used (*.ppl, *.job, and *.qul).

GATES evaluates the classification utility of an assignment when comparing assignments made by competing system designs. Classification utility is expressed by computing the worth of each possible match of personnel to jobs. Assignment worth is expressed as a mathematical function called a payoff function. GATES uses source files to extract personnel and job characteristics when computing payoffs. Information on

personnel attributes in the personnel file is correctly matched to job attributes of the jobs represented in the job file through the qualification file. GATES requires all three files as well as a statement of the payoff function in order to evaluate classification utility.

Personnel Files

Personnel files contain information on personnel/applicants and their associated characteristics. Personnel files can be created by extracting data on actual applicants or accessions from historical records or by generating personnel data with a spreadsheet, database, or statistical analysis product such as the Statistical Analysis System (SAS). To modify a personnel file, the spreadsheet or database software or another application that can read and save comma delimited ASCII files should be used. GATES interprets blank fields as zeros or empty strings depending on the field type. Note: Use a .ppl extension for the filename (e.g., test.ppl)

Job Files

Job files contain information on the jobs to be filled, which in the case of the Air Force are specialties represented by the variable AFSC and the technical training class seats available for assignment represented by the variable ClassSeats. To create a job file, data must be available for AFSC, ClassStartDate, and ClassSeats variables in the job file. Optional data include number of pre-enlistment assignments directly to an Air Force Specialty (AFS). Direct AFS assignments are made within the Guaranteed Training Enlistment Program (GTEP). GTEP seats, job priority, and job release dates are represented by the variables GTEP, PACEJobPriority, and ReleaseIndex respectively. The number of pre-enlistment seats information is used in a two-tier strategy to simulate the release of jobs as occupational area assignments or Open Aptitude Area (Open AI) assignments in the first step. The second step then converts the Open AI assignments to a specialty assignment within that area. Operationally, the first step is accomplished through the recruiter or MEPS while the second step takes place during basic training. Job priority is associated with the fill need of a job relative to other jobs in the job file. PACEJobPriority is randomly generated outside GATES and is a necessary input parameter for the component Variable Fill. ReleaseIndex is a number used to simulate a release date for a job, that is, the day a job opening becomes available for fill. If the researcher cannot recreate the actual order and timing of historical release dates of jobs as they came available for fill, ReleaseIndex can be used to simulate which people "see" each job. Values of ReleaseIndex are compared to values of the sequence variable Subjectnum in the personnel file to determine whether that job is available to that person for an assignment. For example, if ReleaseIndex for a job is 5, only people whose value of Subjectnum is greater than 4 (<= 5) will be considered for that job. Values of ReleaseIndex must be generated or derived from historical values outside GATES . Note: Use a .job extension for the filename (e.g., test.job).

Qualification Files

The qualification file contains job attribute data for each specialty, as well as the open aptitude area categories, needed for the computation of payoff values. Every job in the job file must have a matching entry in the qualification file (using AFSC as the key field) in order for the GATES software to work correctly. Therefore, when adding or changing specialties, make sure the qualification file has a valid AFSC and appropriate data values for variables, parameters, and attributes associated with that specialty. Before making assignments with any of the classification algorithms, GATES uses the qualification file to qualify personnel for a specialty. The variables PrimAptArea and PrimAptMin associate an occupational area and minimum cutoff score for entry into a specialty with an AFSC for that specialty. A person is qualified for a job by comparing the cutoff requirement in PrimAptMin with the person's score on the corresponding composite in the personnel file. For example, if an AFSC in the qualification file has values of M and 65 for PrimAptArea and PrimAptMin, GATES will search the fields in the personnel file for "MScore" and compare MScore and PrimAptMin to determine qualification. A person with an MScore value of 65 or greater would qualify whereas below 65 would not. In GATES the qualification process is not limited to the MAGE occupational areas used by the Air Force. This allows analysts the flexibility to either add (from A1 to Z999) or change occupational areas but still maintain the MAGE areas. To change or add occupational areas and cutoffs it is necessary to add records for the specialties to the qualification file identifying the AFSC for the specialty with the new area and cutoff values. The new values for area and cutoff would be entered in the PrimAptArea and PrimAptMin fields in the record for the new AFSC. Additionally, in cases when an assignment must be qualified in more than one or in either of two occupational areas, GATES may represent a second area and minimum score requirement with the SecAptArea and SecAptMin variables. Note: Use a .qul extension for the filename (e.g., test.qul).

Selecting Source Files

GATES allows the user to specify personnel, job, and qualification files as input data to the current study. All three files appear as selection items under the Source Files menu. Clicking the Source Files menu will display the appropriate menu options to change the personnel, job, or qualification filenames. Clicking a menu option will display a File Open dialog box allowing the user to select a source file. After entering a filename (or selecting a file from the left list box), click OK to accept the new file or Cancel to keep the current file. Alternatively, the View - Source Files menu option displays the current source files as well as button access to change the filenames.

Format Files

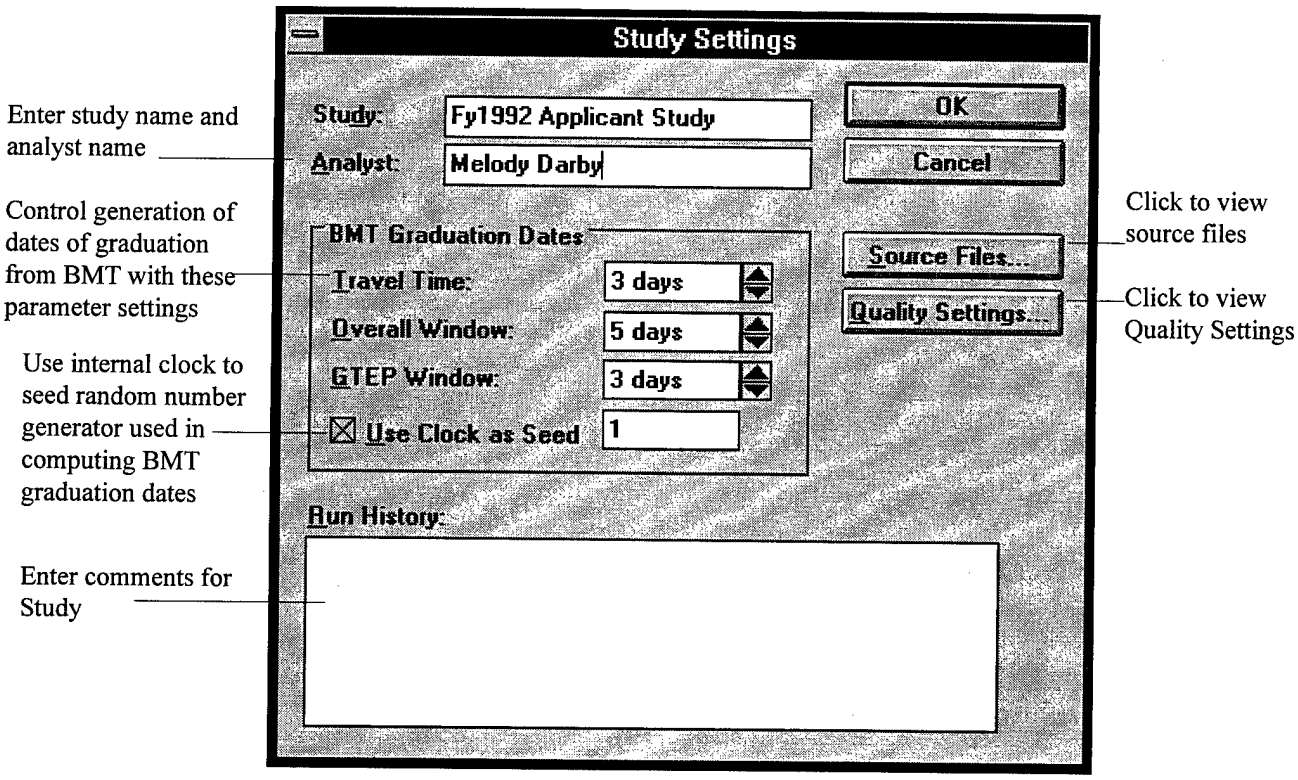
The format files describe the fields and field types for the personnel, job and qualification source files. These files are labeled people.fmt, job.fmt, and quals.fmt respectively. Use a text editor such as EDIT.COM or Notepad to edit these files. Click the Source Files - Format menu option to display the appropriate menu options for selecting the personnel, job, or qualification format files. Selecting a menu option will display a dialog box allowing the user to select a format file. Four types of fields are used in GATES source files, Integer (I), Floating point (F), String (S), and Date (D) fields. With the String field type, a maximum length must also be entered. The user should only add fields to the source files (some aspects of the software will not work correctly if fields are deleted or changed. Old source files would then be incompatible as well).

To add an integer field MyField1 to the personnel file, append the statement "MyField1, I" to the people.fmt file. This field will now be recognized by GATES. Remember to enter the data in the personnel source file (GATES will fill empty fields with zeros when numerical data types are used). See Appendix A for complete variable lists and definitions for all three default format files as they are currently configured in GATES.

Settings

GATES provides a limited capability to simulate certain dynamic aspects of an operational classification system. For example, graduation date from Basic Military Training (BMT) is a variable which must be simulated when assignments are made. Study settings allow the scientist to adjust the parameters that control the values of internally generated BMT graduation dates and the value of the initial seed of a random number generator used by the BMT date generating algorithm. Values may also be set for travel time between BMT and Technical Training, the maximum length of casual time permitted, the cutoff values of the AFQT used as selection screening devices, and the cutoff values on the AFQT used to define high and low quality. The researcher may also choose to use a job release index or to disable the qualification process for the MAGE composite cutoff requirements for individual specialties.

Dates of graduation from Basic Military Training (BMT) are important when attempting to simulate the distribution of personnel graduating from BMT over time that occurs operationally. The researcher uses GATES to internally generate values for BMT graduation dates. GATES assigns BMT graduation dates after the first step assignments have been made in a two-tier strategy and after all assignments have been made in a single-tier strategy. Select the Settings option from the View menu to set parameter values for BMT graduation dates. The Study Settings dialog box will appear.

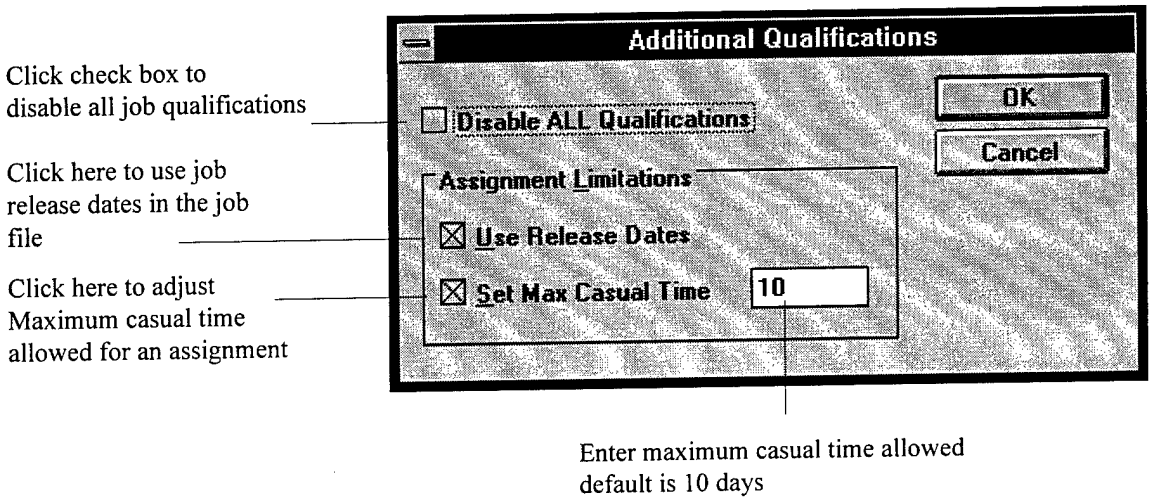


Values of graduation date from BMT are controlled such that the difference between graduation date from BMT for an individual and the class start date for technical training for the job to which the individual is assigned is kept within specified limits. The length of time between graduation from BMT and beginning of technical training is referred to as "casual time" and is an important concern in the operational assignment system. Three parameters, Travel Time, Overall Window, and GTEP Window, control the distribution of BMT graduation dates. Travel Time specifies the number of travel days allotted to an individual between BMT graduation and the beginning of technical training. Overall Window sets the maximum number of days, not including travel time, before the start of the first technical training class when randomly assigning BMT graduation dates for personnel assigned to Open AI jobs in the first step of a two-tier strategy. If the earliest class starts on the 15th, the Overall Window is 5 days, and the Travel Time is 2 days, those assigned Open AI jobs in the first step would be given graduation dates between the 8th and 12th of that month. GTEP Window sets the maximum number, not including travel time, used in randomly allocating BMT graduation dates to personnel assigned to GTEP jobs in the first step of a two-tiered strategy. If the earliest class starts on the 15th, the GTEP Window is 3 days, and the Travel Time is 2 days, those assigned to GTEP jobs would be given BMT graduation dates between the 10th and the 12th of that month. To change the number of days allowed for Travel Time, Overall Window, or GTEP Window, click on the up or down arrow of the spin button. Click the Use Clock as Seed button to activate that computer clock as the seed for the random number generator algorithm used in computing BMT graduation dates. Default values appear in the text boxes for these parameters.

The qualification process, checking to see that a person meets a composite cutoff requirement for assignment to a particular specialty, is used in GATES by default. The qualification process can be disabled such that assignments will be made without checking for qualification. Under this condition, all personnel would qualify for all jobs.

Under operational circumstances jobs are released over a period of time according to manning requirements. Manning requirements are variable and subject to sudden change due to changes in mission requirements. By default GATES allows all personnel to 'see' all jobs at the beginning of an assignment algorithm. That is, all jobs are available to all personnel for possible assignment. GATES can simulate the release of jobs over time with the variable ReleaseIndex in the job file (see job file above for details on ReleaseIndex).

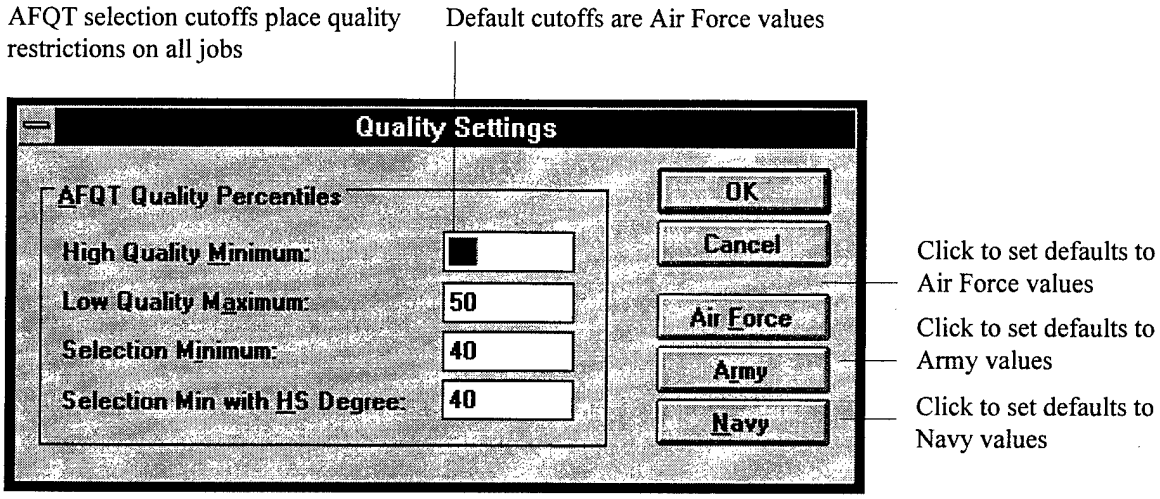
The qualification process may be disabled, the use of a generated job release index may be selected, and the maximum length of casual time permitted set by choosing the Qualifications option from the View menu. The Additional Qualifications dialog box will appear.



Click the Disable ALL Qualifications button to disable the default qualification process. Click the Use Release Dates button to have GATES use values of ReleaseIndex in the job file to simulate the operational release of jobs. Click the Set Max Casual Time button and enter a value in the text box for maximum length of casual time allowed when assigning to jobs. Defaults appear in text boxes.

Selection cutoff, as in the individual Services' AFQT category cutoffs, or quality goals and caps can be manipulated so as to place quality restrictions on all jobs. For information on placing quality goals or caps on only certain AFSs as well as minority and gender goals and caps see Section III, Optimal LP. To set AFQT cutoffs select the

Quality Settings option from the View menu. The Quality Settings dialog box will appear.



Click the Selection Minimum check box to enter a percentile AFQT cutoff value for a selection minimum. To specify a selection minimum with a high school diploma, click the Selection Minimum with HS degree check box. These minimums may be set to zero to disable the AFQT selection process. To set high and low quality percentile cutoffs on the AFQT, click on the High Quality Min and Low Quality Max check boxes and enter desired values. Values for these parameters can be set to values currently used in the services by clicking on the radio button for the desired service, Air Force, Army, or Navy. Default values appear in the text boxes.

Printing the Study Settings

To print the current study settings, choose the Study - Print menu option. If a default printer is not selected, click the Setup button from the Print dialog box or choose Study - Print Setup.

Historical Assignments

The Strategy - Historical menu option produces the operational job assignments actually received at the MEPS and/or Basic Training by the personnel present in the personnel file of the current study. The HistAFSC variable in the personnel file contains values for operational assignments. If this field is blank in the personnel file, GATES assumes that no operational assignment was made and skips the applicant in evaluating his contribution to a MOM. To run a historical match, since GATES does not simulate the payoff computation of the operational classification system, it is first necessary to specify a MOM with which to evaluate the classification utility of those assignments. The same MOM can then be used as a payoff or objective function by a competing classification algorithm for purposes of comparison. In the interest of fairness note

that Historical Match does not use the specified MOM when making assignments.

Generated Data Files

In addition to using historical or operational personnel and job data to evaluate the classification utility of an assignment, generated payoff values may be used. These payoff values reflect the worth of assigning a particular individual to a particular job that is not a specialty with attributes in the qualification file. The payoff values must be generated externally from GATES. The generated payoff values may then be imported into a GATES personnel file. Many statistical packages and spreadsheets offer capabilities to generate data from a specified distribution, for example, SAS or EXCEL. In a study using actual specialties, GATES uses the qualification file to link appropriate job attributes with the jobs in the job file. Then, payoffs may be computed for assignments of the personnel in the personnel file to the jobs in the job file. In order to avoid error when working independently of the job attribute data in the qualification file, each 'column' of generated payoff values in the personnel file must be stored in newly created fields, rather than existing fields, that correspond with a new person characteristic variable, (e.g., payjob1, payjob2. ...). The name of the person characteristic variable must be declared in the personnel format file. After payoff values have been added to the personnel file, the payoffs must be associated with a 'job' to which they correspond within the qualification file. The pre-defined function TestStdArea within the qualification file serves to declare this association. TestStdArea will return payoff values associated with specific person-job combinations. To use TestStdArea, the name of the new person characteristic variable must be declared in the TestStdArea field of the record in the qualification file for the job to which the payoff value corresponds.

III. CLASSIFICATION SYSTEMS

After the user has set up source files and specified study settings, the classification system design specifications must be made. Classification system design specifications for GATES fall into four broad categories: strategy, the number of assignment tiers or steps in the system; classification algorithms used to make assignments at each step; payoff/objective functions used by algorithms to determine the value of an assignment; and constraints on the system. All four topics are covered in this section.

Single-Tier and Two-Tier Classification Strategies

A single-tier classification strategy assigns applicants in one step where each applicant receives an assignment directly to an occupational specialty. A two-tier strategy assigns a proportion of applicants directly to specialties and a proportion to occupational areas in the first step. In the second step, applicants with occupational area assignments from the first step are given specialty assignments in the second step. Thus, a single-step assignment strategy employs a single classification algorithm while a two-step strategy must employ two separate classification algorithms, one at the first step and a second algorithm at the second step (see Figure 2).

The Air Force uses a two-tiered assignment strategy. At the first step assignment a sequential classification procedure is used to assign applicants directly to Air Force Specialties (AFSs) or into occupational areas: Mechanical, Administrative, General, and Electronic. All AFSs assigned at this first step are Guaranteed Training Enlistment Program (GTEP) AFSs. The occupational area assignments are referred to as Open Aptitude Index (Open AI) assignments. The proportions of GTEP/Open AI assignments at the first step vary but have historically been about 45% GTEP and 55% Open AI. At the second step a batch sort algorithm, the Processing and Classification of Enlistees (PACE), is used to assign to AFSs all those applicants given Open AI assignments at the first step. A detailed description of the procedures for specifying a classification strategy and the assignment algorithms available at each tier or step along with Air Force defaults in GATES follows.

Single-Tier Strategy

Classification algorithms available with a single-tier strategy are divided into sequential and batch algorithms. A sequential algorithm assigns person one first before looking at any other applicant. In other words, it uses a first-come, first-served approach. The AF Payoff algorithm is an example of a sequential algorithm. Batch algorithms assign a group of applicants to jobs without regard to order. That is, person one does not have to receive a job before person two. Sorting is an example of a batch algorithm.

Two-Tier Strategy

A two-tier classification strategy involves choosing two algorithms: at the first step applicants are assigned to either a GTEP or Open AI before entering the service and at the second step Open AI enlistees are assigned to specific jobs during Basic Military Training (BMT). For all algorithms in the second step, those applicants who received a GTEP job are assigned first so they retain their jobs, then Open AIs are assigned using the selected batch process. A recruit with an Open AI in the first step can receive only jobs in the area initially assigned (Mechanical, Administrative, General, or Electronic). For example, a person assigned to the M area can receive only mechanical jobs in GATES. Only batch algorithms are available for selection at the second-tier of the two-tiered strategy.

Selecting a Classification Strategy

GATES allows the user to select a single or two-tiered strategy. Both items appear under the Strategy menu. The user must open the Strategy menu and click on the appropriate menu option, either one-step or two-step. Selecting a single or two-tiered strategy will display a single or two-tiered strategy dialog box with classification algorithms available for selection.

Overview of Classification Algorithms

Several classification algorithms are available for use in the classification system design. These methods may be broadly categorized as either sequential or batch methods. Sequential methods can only be selected for the single-tier strategy or for the first step of a two-tier strategy. Sequential methods use the arrival sequence of applicants and finish processing the first applicant before looking at the second, and so on. Sequential methods may or may not use release dates for jobs. Batch methods can be used for a single-tier strategy and for either step of a two-tiered strategy; however, the second step of a two-tier strategy must use a batch method. Batch methods ignore the arrival sequence of applicants and the release dates of jobs and consider all applicants and all jobs together.

Sequential Algorithms

The sequential algorithms available in GATES are AF Payoff, User Payoff, and Sequential Random algorithms. AF Payoff employs the payoff algorithm described in Hendrix, Ward, Pina, and Haney (1979). User Payoff allows the user to build an AF Payoff-like function that is a combination of components specified by the user. Sequential Random makes assignments selecting a job at random for each individual. Sequential Random determines that the individual is qualified for the job before making the assignment.

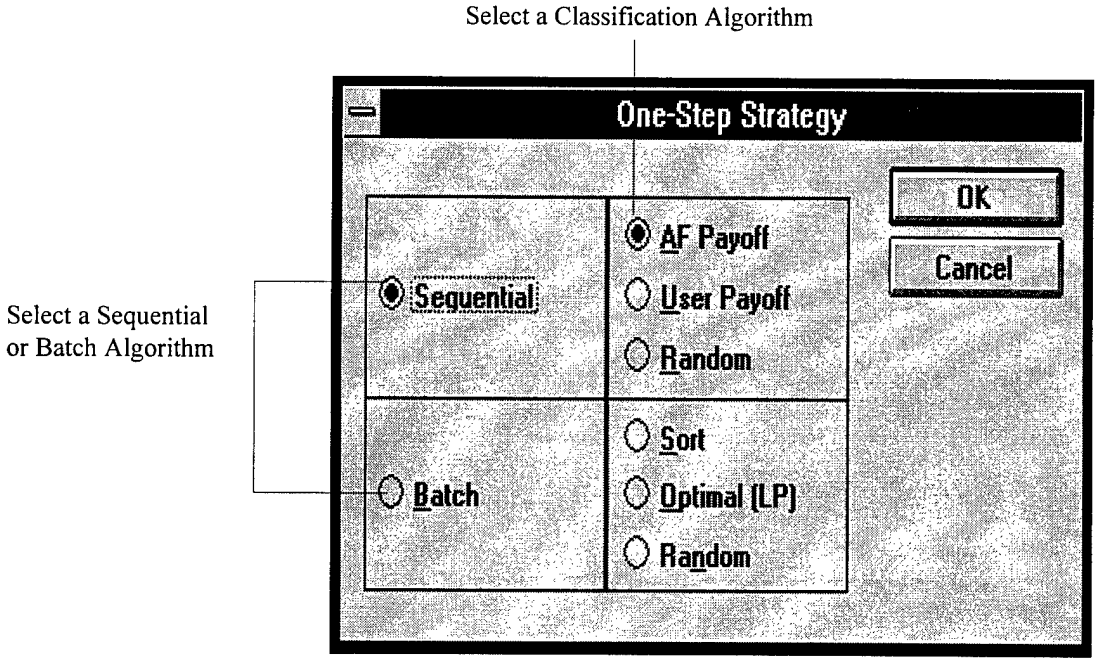
Sequential Random determines that the individual is qualified for the job before making the assignment.

Batch Algorithms

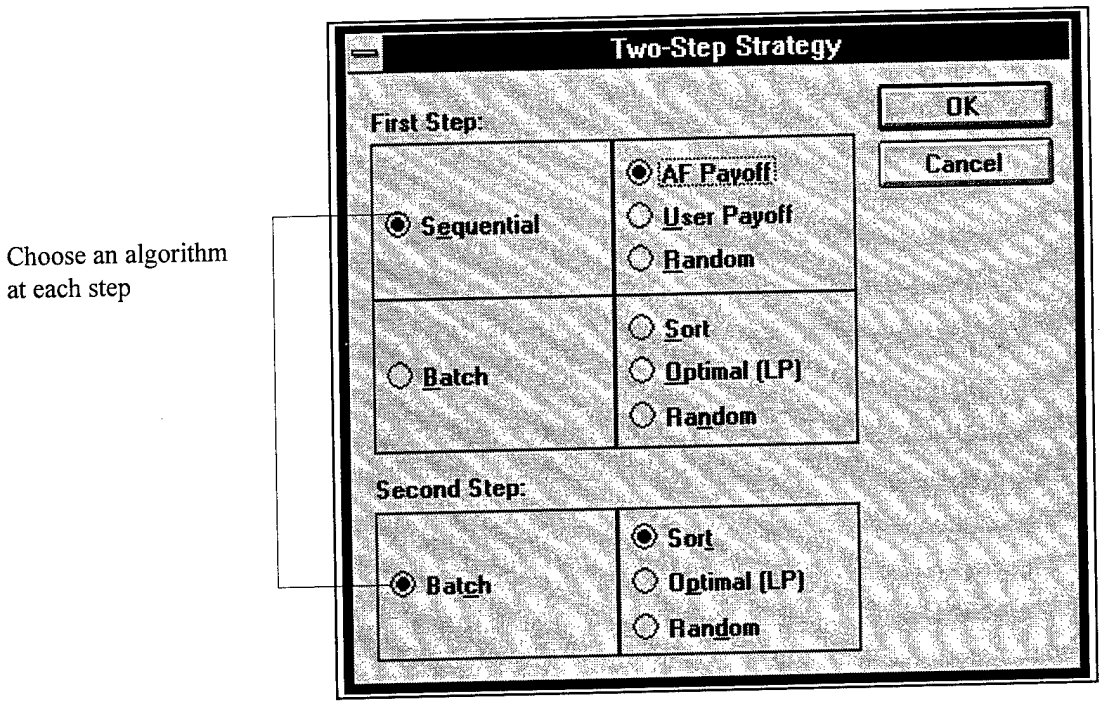
Batch algorithms include Sort, Optimal LP, and Batch Random. Sort employs the Air Force PACE algorithm described in Pina, Emerson, Leighton, and Cummings (1987) as a default. The user can also select components, sequence, and order (ascending/ descending) for a user specified sort. Optimal LP is a network flow algorithm which assigns applicants to jobs using an objective function consisting of components available in GATES (Kennington & Whisman, 1987; Kennington, 1993). Assignments are made so as to maximize (or minimize) the value of the objective function for the entire matrix of assignments. Batch Random chooses an applicant at random from among the group of applicants and assigns the applicant to a job chosen at random from the group of jobs available. Each applicant is first determined to qualify for the assignment.

Selecting Classification Algorithms

The user must specify single-tier or two-tier strategy at the Strategy menu. Upon selection of a strategy, one of the following classification algorithm dialog boxes will appear.



In the single-tier or one-step dialog box shown above, click the radio button to the left of the desired algorithm and press <enter<. The parameters for the algorithm will then be displayed. Clicking cancel will clear the algorithm selection and return the user to the menu bar while the OK button accepts the algorithm.



In the two-tier or two-step strategy dialog box, click the radio button to the left of the desired algorithms for both the first and second steps and press <enter>or click OK to accept the choice of algorithms. A dialog box of the parameters for the first selected algorithm will open followed by a dialog box of the parameters for the second algorithm.

Detailed Description of Classification Algorithms

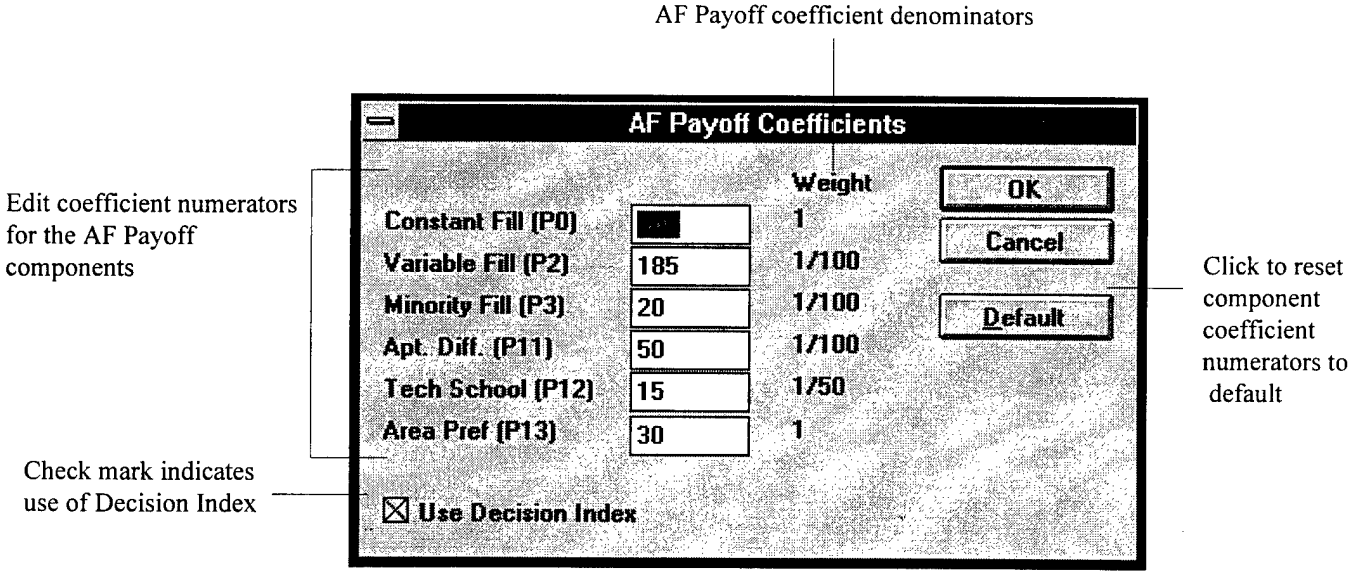
AF Payoff Algorithm

The AF Payoff algorithm was developed by the Air Force Human Resources Laboratory in the late 1970s. The work was documented and published in 1979 (Hendrix et al., 1979). AF Payoff in GATES recreates as closely as possible the algorithm as developed by the Laboratory (see Appendix B). AF Payoff is a sequential algorithm that approximates an optimal batch solution. The payoff function used by the algorithm consists of a constant term summed with five components and their coefficients. The function yields numerical values, payoffs, ranging from 700 to 1000. A payoff represents the worth, classification utility, for the assignment of a particular recruit to a particular job. GATES first determines that an applicant qualifies for a job before computing a payoff. Payoffs can be scaled with a historical mean for the purpose of comparing applicants with their peers when determining assignment. The resulting scaled payoff is called the Decision Index. Historical means pertain to individual Air Force specialties and are referred to as 'column means' in the literature (Ward, 1959) and the GATES qualification file.

AF Payoff Parameters

Payoffs computed are a function of a constant term plus the following five components: the aptitude of an individual in combination with the difficulty of a job, predicted success at technical training, the individual's preference for the occupational area to which a job specialty belongs, a measure of the fill rate of the class seats available for a specialty, and a measure of how many minority applicants have been assigned to the specialty in combination with the minority status of the current applicant considered for assignment. Five coefficients, one for each of the five components, are included in the payoff function. The denominators of the five coefficients are equivalent to the maximum values obtainable by the corresponding component. The numerators of the coefficients are a matter of management decision or organizational policy and determine the proportional contribution to the total payoff of the corresponding component. Coefficient numerators used in GATES are those originally developed by the Air Force in the late 1970s.

After selecting AF Payoff from the classification algorithm dialog box, the following AF Payoff Parameters dialog box will appear. The text boxes contain the numerators for the five components plus a box for the constant term. The denominators of the coefficients appear in fractional form to the right of the coefficient numerator text boxes. The portion that each component will contribute to the total payoff can be manipulated by editing the values of the coefficient numerators in the text boxes. The values developed by the Air Force appear as defaults and can be restored by clicking on the default radio button. After the coefficient numerators have been entered, click on the OK button to accept the parameter settings. If the Use Decision Index box is selected, GATES will subtract the value of the column mean from each payoff to yield a value for the Decision Index. Assignments will then be made based on values of the Decision Index.

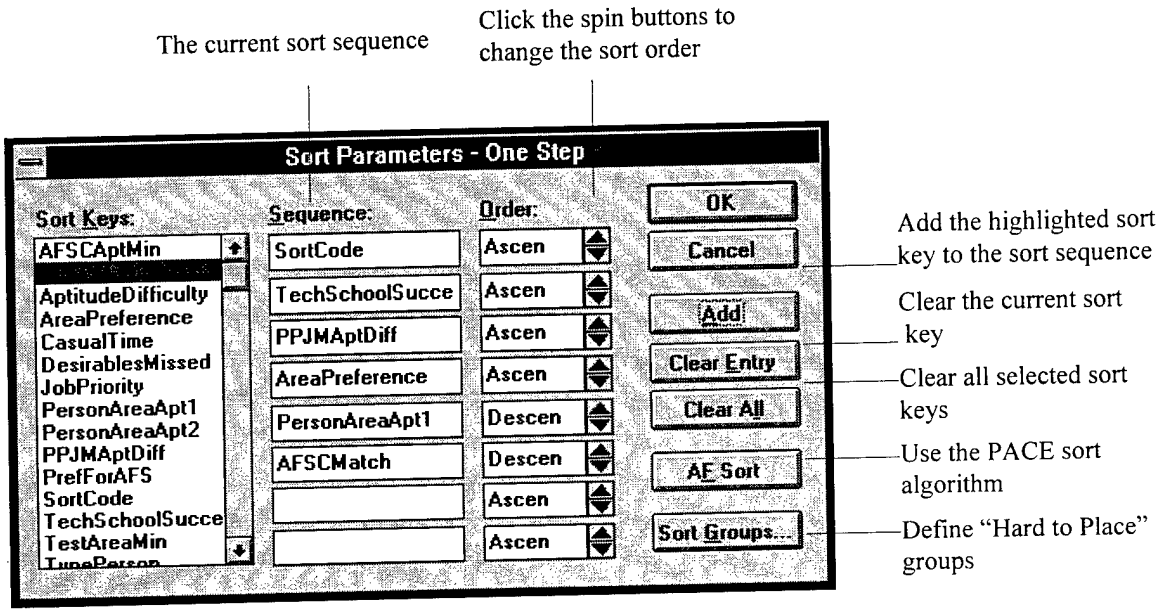


Sort Algorithm

The Sort algorithm assigns applicants in a batch mode using the selected sort sequence. A record is generated by GATES for every possible person - job combination conditioned on MAGE composite cutoff requirement. These records are then sorted according to the sort keys chosen by the user. The sort keys may be any currently defined functions in either ascending or descending order. During the sort, the first key is used for comparing the records. When a tie results, the second key is used, and so on. After all records are sorted, the algorithm assigns the records (the applicant to the class seat) beginning with the first. A record is skipped (no assignment made) if the record contains a person already assigned or a class without any seats left. This process continues until all records are processed.

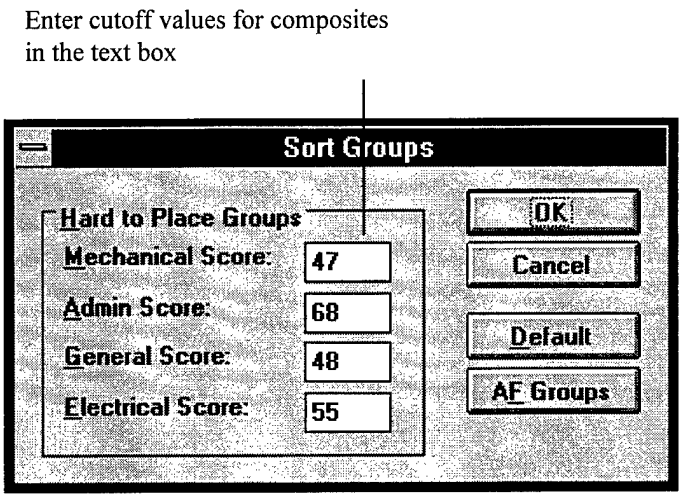
Sort Algorithm Keys

The Sort Parameters dialog box allows the user to select the sort keys and sequence for the Sort algorithm. Highlight the desired key (component) in the Sort Keys list box and click the Add button (or double-click the sort key). The model will automatically place the key in the next available text box. Next, use the spin buttons by clicking on either the up or down arrow to choose the order (either Ascending or Descending) for the sort key. The Sort algorithm sorts on the top key first followed by the next key down (to break any ties), and so on.



The Clear Entry Button clears the text box with the current focus (where the cursor is). The Clear All Button clears all the sort keys and resets the orders to Ascending. The AF Sort Button selects the Air Force Sort (PACE) sequence and order. See Appendix C for a detailed description of the Air Force PACE sorting routine. The

Sort Groups Button allows the user to define a "Hard to Place Group" using the Armed Services Vocational Aptitude Battery (ASVAB) composite scores. Click on the Sort Groups Button and a dialog box for the composite score settings will appear. Fill the text



box beside each composite with the cutoff score defining the "Hard to Place Group" for that composite. The sort algorithm then divides the personnel file into two groups according to the specified composite cutoffs. Those people whose composite scores fall below the cutoff values for each of the composites form the "Hard to Place Group" while those whose composite scores fall above the cutoffs form the second group outside the "Hard to Place Group". The Sort algorithm will then assign the "Hard to Place Group" to jobs before making assignments for the group outside the "Hard to Place Group". Place zeros in the text box beside each composite in the composite score settings dialog box to designate no Sort Groups. Zero cutoff settings are the default.

Batch Random Algorithm

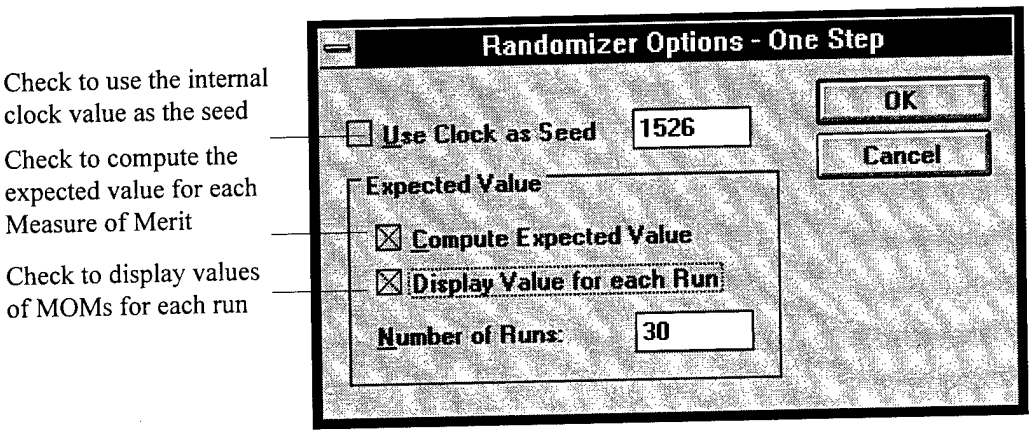
The Batch Random algorithm assigns a random applicant to a random class seat without regard to the order of the applicants. GATES picks an available class seat at random and then determines the qualified applicants for that job. A qualified applicant is then assigned at random to that class seat. This process is repeated until either all seats are filled or all qualified people are assigned.

For purposes of comparison to other algorithms, at least one MOM must be indicated with the random algorithm. An expected value can be computed for each designated MOM. An expected value is computed by averaging the statistics for each MOM over some number of executions of the random algorithm. GATES runs the Batch Random algorithm and computes each MOM for the resulting assignment. GATES executes the Batch Random algorithm again and adds the current statistics on the resulting assignment for the designated MOMs to their previous totals. This process is repeated n times (controlled by the user at run time). The average for each MOM computed over the n runs is reported in the Summary file.

Random Algorithm Options

To enter a particular seed for the random number generator (used to pick a random applicant or class seat), click the Use Clock as Seed check box and then enter a number in the text box to the right. Otherwise, just click the check box to use the internal clock as a seed.

To run the random assignment n number of times, click the Compute Expected Value check box and enter the number of runs in the text box. GATES will repeat the random assignment (using a different seed) the desired number of times and keep statistics on the separate matches. To report the expected value for each Measure of Merit, the statistics for the n separate runs are averaged. The final match is then used to continue the simulation.



The above screen uses 1526 as the seed for the random number generator and computes the expected value for 30 runs

Sequential Random Algorithm

The Sequential Random algorithm assigns applicants in the order they appear in the personnel file. Class seats are chosen at random. GATES determines the jobs for which the first applicant is qualified and totals the number of available seats. A random number between 1 and the number of seats determines the choice of seat (and thus specialty) assigned to the applicant. This process is repeated until either all seats are filled or all qualified people are assigned.

The Expected Value (if selected) for Sequential Random operates as described above under Batch Random algorithm. See the Random Options dialog box above to select Sequential Random parameters.

Optimal Linear Programming Algorithm

The Optimal LP algorithm is the only algorithm offered in GATES which computes an optimal solution (Hillier & Lieberman, 1990). GATES uses network flow code written by Southern Methodist University (SMU) for the Navy Personnel Research and Development Center (NPRDC) and provided to the GATES effort by NPRDC in July 1993 (Kennington & Whisman, 1987; Kennington, 1993). The algorithm is a batch algorithm and can be selected in either step of a two-tiered strategy as well as a single-tier strategy. The algorithm assigns applicants to jobs based on the value of an applicant's payoff associated with the job. The assignment objective of Optimal LP is to maximize the sum of the payoff values for the assignment solution. The Optimal LP algorithm accomplishes a maximization of the sum of the payoffs through its ability to consider all assignment solutions simultaneously. Figure 3 contrasts an optimal assignment solution for a three person by three job array of payoffs with a sequential solution.

PREDICTED PAYOFF ARRAY

JOBS

PERSONS		Job1	Job2	Job3
	Person1	8	7	6
	Person2	5	1	0
	Person3	6	4	1

SEQUENTIAL HIGHEST PAYOFF SOLUTION

JOBS

PERSONS		Job1	Job2	Job3
	Person1	8	7	6
	Person2	5	1	0
	Person3	6	4	1

OPTIMAL LINEAR PROGRAMMING SOLUTION

JOBS

PERSONS		Job1	Job2	Job3
	Person1	8	7	6
	Person2	5	1	0
	Person3	6	4	1

Figure 3. Illustration of an Optimal Assignment Solution

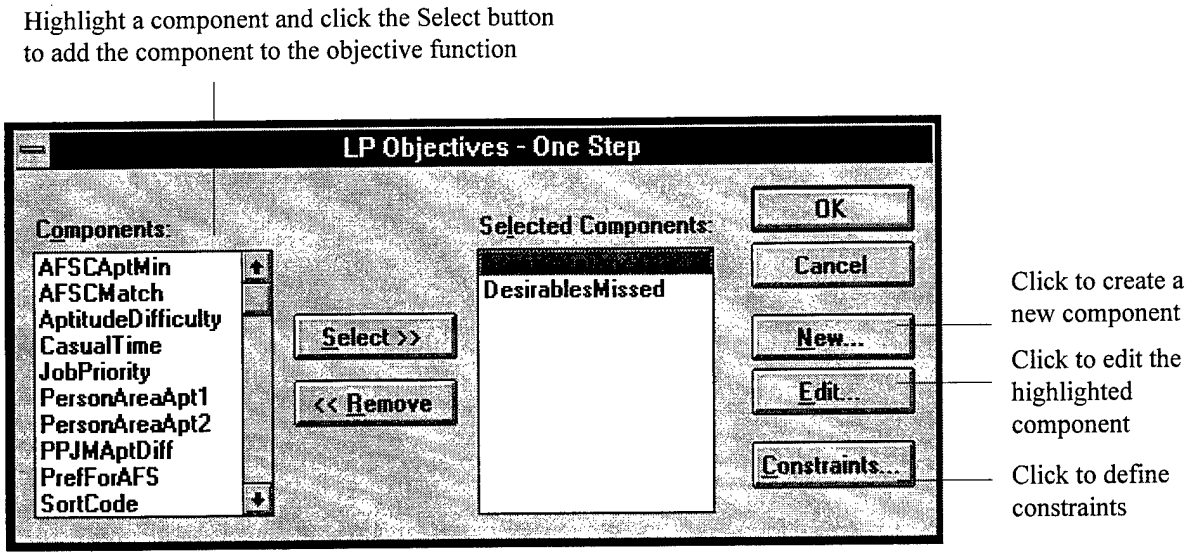
As can be seen in the figure, each individual's highest payoff occurs for the first job. Consequently, a sequential assignment results in person 1 assigned to job 1, person 2 assigned to job 2, and person 3 assigned to job 3. Thus a sequential, first-come-first-serve, algorithm yields a value of ten for the sum of payoffs of the assignment solution. In contrast, the optimal algorithm, which considers all possible assignment solutions simultaneously, can yield a maximum value of 15 for the sum of payoffs of the solution by assigning person 1 to job 3, person 2 to job 1, and person 3 to job 2. The optimal

assignment solution does not necessarily correspond to each individual's highest payoff but will yield a sum of payoffs for the assignment solution that has a maximum value among all possible solutions.

Optimal LP uses a network flow algorithm. Network flow algorithms are often used to assign people to jobs when the payoff for an assignment can be expressed as a linear combination of the decision variables (flows on the network arcs) and the goal (objective function) is to maximize (or minimize) the sum over the entire assignment of the payoffs. When the only constraints are those which conserve the flows on the arcs, the solution produced is optimal and integer. When there are additional constraints, called side constraints, the optimal network flow solution may not be integer because it may include fractional flows that split a person between two or more jobs. The resulting noninteger solution must be rounded to an integer solution and may then no longer be an optimal solution. In GATES, the user may specify side constraints, thus creating a solution that may be noninteger. GATES then rounds the noninteger flows from the LP to integer yielding an integer but possibly non-optimal solution. If the objective function is relatively insensitive to small changes near the optimum value (which is usually the case for "real world" assignment problems), rounding a network flow solution to integer flows produces a "good" solution. Note that the more side constraints one uses, the less faith one should place in the optimality of the rounded answer. GATES reevaluates side constraints after rounding a noninteger solution to determine whether the constraints hold within the rounded solution. If the constraints are not met, the model sends a message to the screen and writes a message on the detailed output file. If side constraints are not met, the user should consider rerunning the problem with looser constraints (lower goals and higher caps) to determine whether the new rounded solution will meet the original constraints. GATES allows the user to define the following types of side constraints for any specialty: Gender goal or cap, Minority goal or cap, High Quality goal or cap, and Low Quality goal or cap.

Optimal LP Objective Function

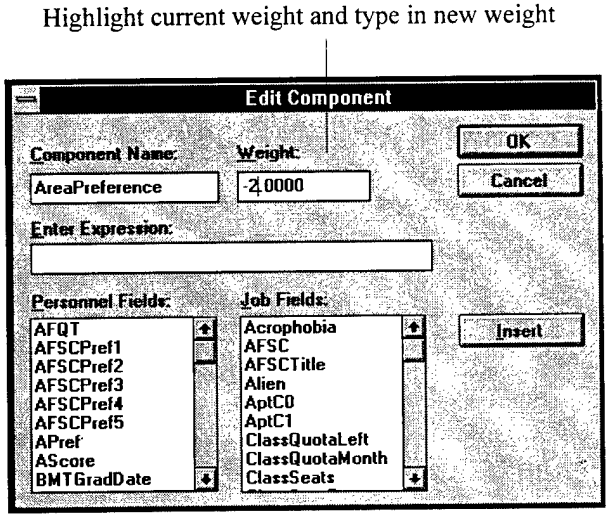
The Optimal LP algorithm computes payoffs from an objective function and uses the value of the payoffs to assign applicants to jobs. The objective function consists of a component, series of components, or multiplicative interactions of components each multiplied by a coefficient and all summed to obtain the payoff. To define an objective function, the user highlights desired components from the Components list box of the Optimal LP Objectives dialog box and clicks the select button. This moves the selected component from the Components list box to the Selected Components list box. To remove the component, highlight the component in the Selected Component list box and click the Remove button.



Note that Optimal (LP) minimizes the objective function to find the optimal match. For functions which should be maximized, multiply the weight by -1 from the Edit Component dialog box (see below). The weights of the Pre-Defined functions are set as one would expect (e.g., TechSchoolSuccess has a weight of -1).

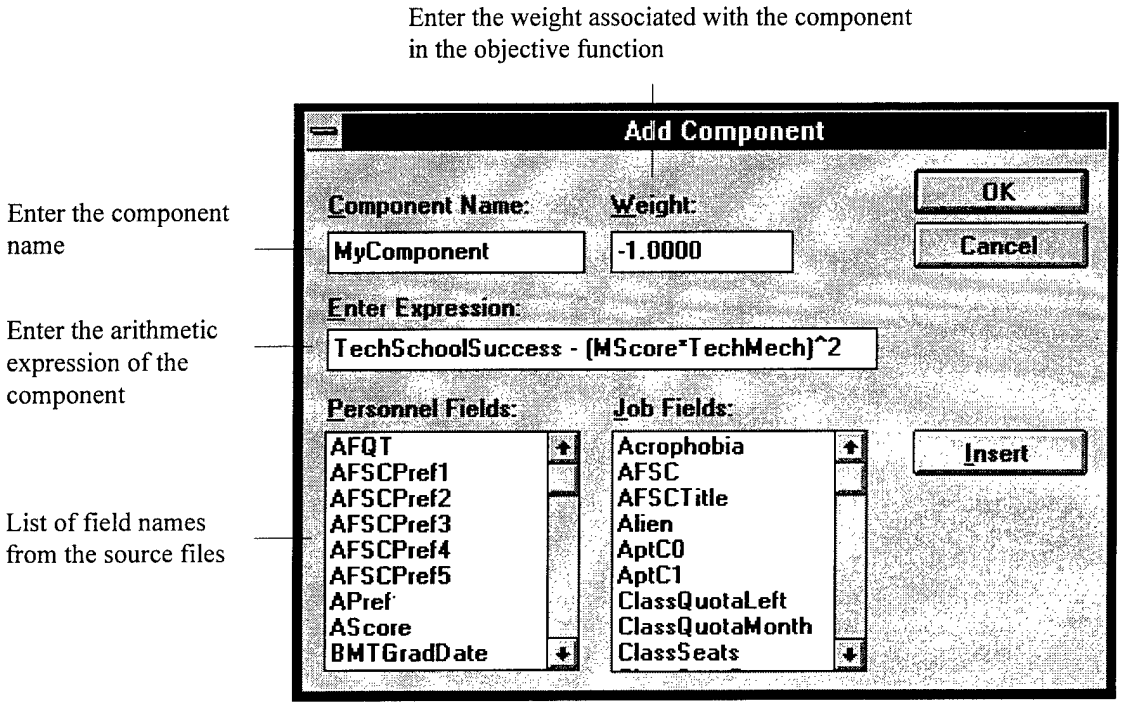
Editing Components

To edit the weight of a selected component (default weight is 1), highlight the component in the right list box to edit with the mouse and click the Edit button. The Edit Component dialog box will appear. Next, highlight the current weight in the Edit Component dialog box and type in the new value. Click the OK button when finished to accept the changes.



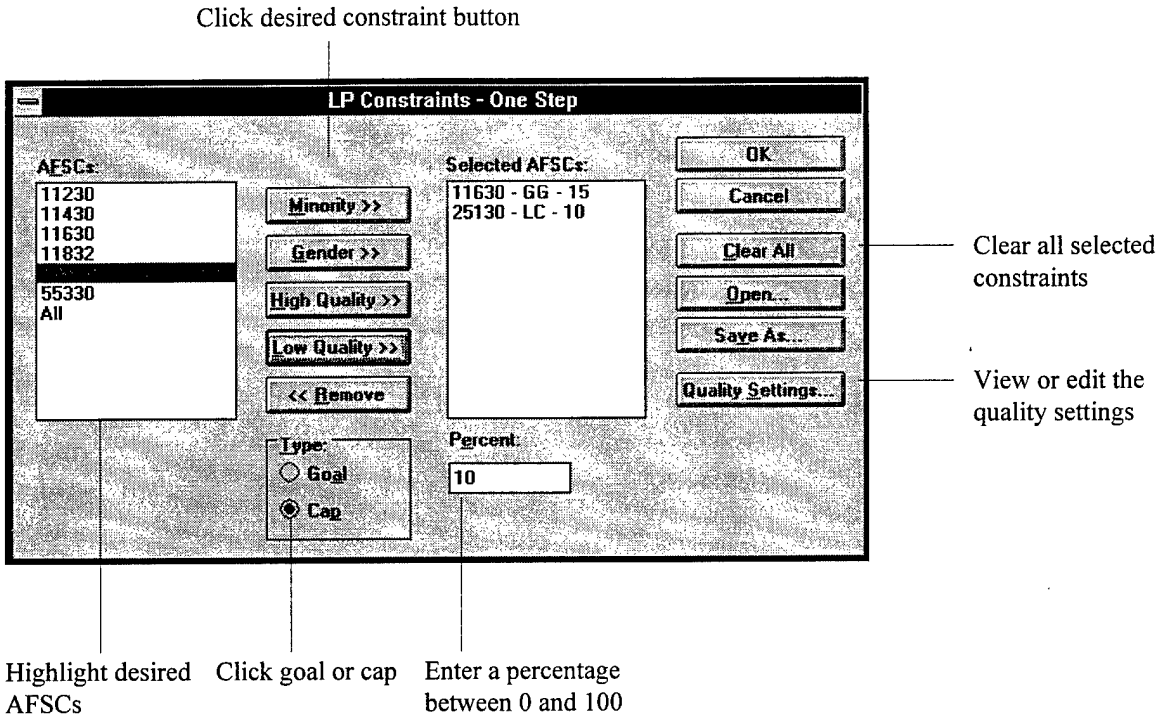
Creating New Components

To create a new component, press the New button on the right side of the LP Objectives dialog box. The Add Component dialog box will appear. Enter the name of the new component in the Component name text box. Component names are case sensitive and mandatory. If no name is entered, press OK and GATES will delete the old component or cancel the new component. Next, enter the expression of the component which can contain Field Names (described in the format files, see Appendix A), arithmetic operators, or existing components. Lastly, determine the weight of the component (the default weight is 1). These weights are determined separately for each of the algorithms except for the Sort algorithm which does not use a weight. Note that predefined components such as TechSchoolSuccess only allow the user to edit the weight and will ignore any text in the Enter Expression text box. See Appendix D for additional details, arithmetic operator lists, rules for numerical expressions, and examples of creating new components.



Optimal LP Constraints

To define constraints for the Optimal (LP) algorithm, click the Constraints button from the LP Objectives dialog box. The constraints apply to all the people assigned to the specialty during the simulation. Thus, in a second step LP, the assignments made during the first step are included in calculating the percentage assigned for the constraint.



Selected constraints: Gender goal of 15% for AFSC 11630 and Low Quality cap of 10% for AFSC 25130.

GATES can set four types of constraints as indicated by the four Constraint buttons. Each type of constraint can either be a Goal or Cap. A Goal forces a minimum percentage of people of that type to be assigned whereas a Cap sets the maximum percentage of people of that type to be assigned. The four types of constraints are:

Minority	The race of the Person (0 for Non-Minority, otherwise Minority)
Gender	The gender of the Person (0 for Female, 1 for Male). Constraint is applied to females.
High Quality	Defined in Quality Settings dialog box, people with a high AFQT score and a HS Degree
Low Quality	Defined in Quality Settings dialog box, people with a HS Diploma but a low AFQT score

To enter a constraint:

1. Highlight the desired AFSC in the left list box
2. Click on either the Goal or Cap radio button
3. Enter a percentage in the Percent text box (from 0 to 100)
4. Click the appropriate constraint button

The constraint will appear in the Selected AFSCs list box. To remove a constraint, click on the constraint in the list box and press the Remove button (or double-click on the constraint). The current constraints can be saved by clicking the Save As button. This allows the user to define multiple sets of constraints per study or use one constraint file for multiple studies. To retrieve previously saved constraints, click the Open button and enter the filename.

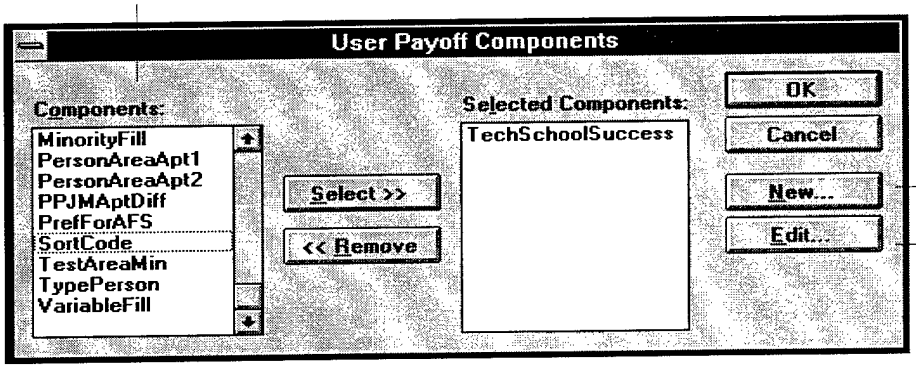
User Payoff Algorithm

The User Payoff algorithm sequentially assigns an applicant to a specialty or to an occupational area. Assignment is accomplished according to the highest payoff for the available jobs computed from a user specified payoff function. The payoff function is defined by the user after selecting User Payoff as an assignment algorithm. The payoff function may contain any currently defined, newly created, or multiplicative interactions of components. The selected components (after multiplying by their coefficients) are added to compute the payoff for the person - job combination. After all payoffs for the applicant are computed, the applicant is assigned to the job with the highest payoff.

User Payoff Function

The User Payoff algorithm sums the values of each selected component multiplied by its respective coefficient to arrive at the total payoff. This value is then used in the assignment algorithm to assign each person to the job for which they have the largest payoff. To define a payoff function, from the Components list box of the User Payoff Components dialog box, highlight each desired component and click the Select button. This moves the component from the Components list box to the Selected Components list box. To remove the component, highlight and press the Remove button thus moving the Component back to the left list box.

Highlight the desired component and click the Select button to add the component to the payoff function



The payoff function for the above screen is 1*TechSchoolSuccess

As with the Optimal LP algorithm, from the new and edit component dialog boxes, the user can create new or edit existing functions or components. Click on the New or Edit buttons and the appropriate dialog box will appear. See Optimal LP algorithm, Creating New Components and Editing Components for a description of the Add and Edit Component dialog boxes. Also see Appendix D for additional details and examples.

IV. MEASURES OF MERIT, OUTPUT FILES, AND REPORTS

Overview of Measures of Merit

To assist the researcher in evaluating the benefit or value of alternate classification strategies and algorithms, GATES provides the capability to generate Measures of Merit (MOMs). MOMs are estimates of the merit or worth from assigning a person with given attributes to a job with given requirements. MOMs are typically estimates that are related to performance, effectiveness, or potential productivity of the person in a job. GATES allows the user to select components, personnel data fields, or job data fields as MOMs. It also allows the user to build MOMs that are functions of these same items. GATES will compute all requested MOMs for the assignments it generates. These MOMs are output to the Detailed Report file for the user to access as report or data information on the full assignment and are summarized in the Summary Report file. GATES can also compute MOMs for assignments saved from an earlier study without rerunning the assignment algorithm. MOMs are necessary for evaluating the quality of the assignment generated by the Random algorithms as well as the operational assignment, Historical Match. Since there is no designated payoff or objective function used by these algorithms, it is necessary for purposes of comparison to define a MOM.

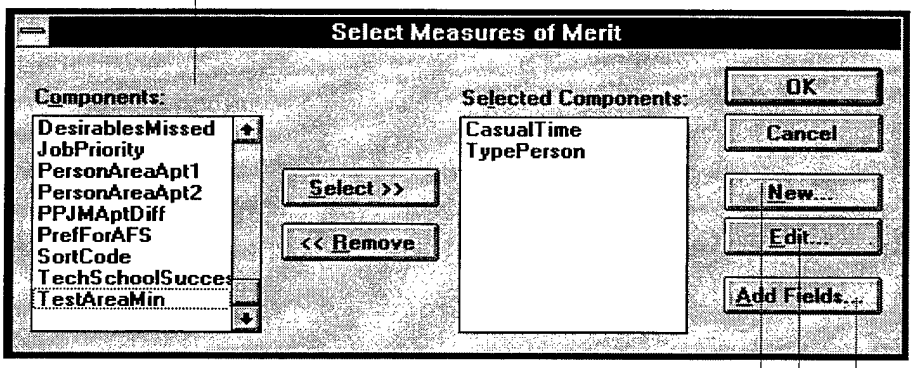
When making effectiveness or efficiency comparisons of competing assignment algorithms using MOMs, one must bear in mind that the MOM may or may not have been the function used by the algorithm when determining assignments. For example, Historical Match may be compared to Optimal LP on the basis of the MOM which the Optimal LP algorithm used as the objective function. In the interest of accuracy, the user must note that the MOM was not used by Historical Match.

Selecting Measures of Merit

The user may select MOMs to be reported for assignments made with any strategy/algorithm. To select a MOM, first select the Select MOM option from the Run pull down menu. A Select Measures of Merit dialog box will appear.

To select MOMs, highlight the desired component(s) from the Components list box and click the Select button. This moves the component from the left to the right list box. To remove the component, highlight and press the Remove button thus moving the component back to the left list box. Any component may be reported as a MOM regardless of the algorithms or payoff/objective functions used to make assignments. Once a MOM has been defined it will appear as a component in the Component list box of all dialog boxes containing a components list box.

To select Measures of Merit highlight desired components from Components list box and click the Select button



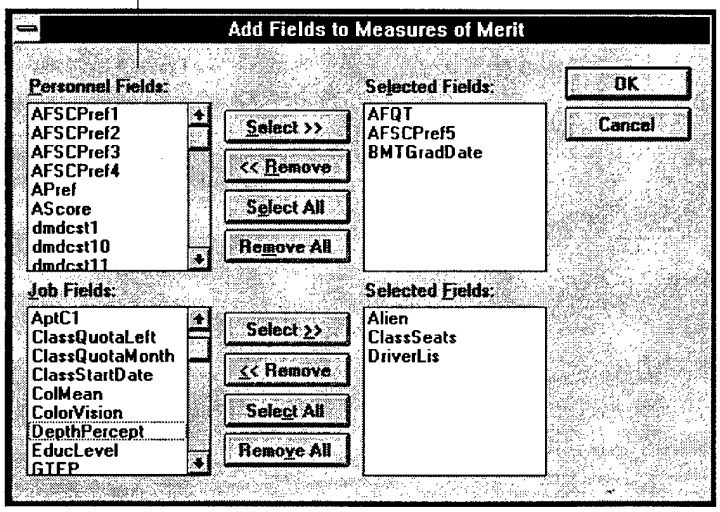
Click to create a new component

Click Edit button to edit an existing component

Click Add Fields button to view individual characteristics

The Add Fields option in the Select Measures of Merit dialog box provides a convenient way to track assignments with individual person and job data fields. This eliminates the need to switch back and forth between the personnel, job, and qualification input files and the detailed output files in order to track individual characteristics such as aptitude measures or BMT graduation dates. Viewing associated individual characteristics with an assignment is helpful in quickly determining why seats went unfilled or applicants went unassigned. Click the Add Fields button and the Add Fields to Measures of Merit dialog box will appear.

To select individual characteristics highlight the desired personnel or job fields from the list boxes and click the Select button



To select fields from the Add Fields to Measures of Merit dialog box, highlight the desired fields and press the Select button. To remove a selected field, highlight and click the Remove button. The top list box contains the fields from the personnel file while the bottom list box displays the fields from the job and qualification files. The data fields are described in their respective format file see Appendix A.

Creating New Measures of Merit

As with the User Payoff and LP Objective Function dialog boxes, the user can create new or edit existing components from the Measures of Merit dialog box. Click on the New or the Edit button of the Select Measures of Merit dialog box and the appropriate dialog box will appear. Components may be added or edited in the same manner as for the Optimal LP or User Payoff algorithms. See the subsections entitled "Creating New Components" and "Editing Components" in Section III. The new component can then be used to measure the quality of an assignment regardless of the assignment algorithm used. The component may also be used as a payoff or objective function for the User Payoff and Optimal LP algorithms or a sort key by the Sort Algorithm. For additional details on creating new components see Appendix D.

Overview of Output Files and Reports

GATES creates several files (with an .out extension) from an execution of an assignment. For a single-tier strategy, the Summary Report and Detailed Report files will be written. For a two-tier strategy, the file ALG1.OUT will also be written (in the current directory) to provide the user access to the detailed results for the algorithm used to make assignments at the first tier. All assignments, whether from a one or two-tiered strategy, are reported in the Detailed Report. These file names may be changed through the Run menu.

GATES also produces ancillary data files and source code for additional analyses. Previous Match is a data file which provides a convenient option for users. It precludes the necessity of re-executing an assignment for the purpose of capturing the values of additional MOMs or data items of interest. A payoff matrix of payoff values for all people and all jobs in the current personnel and job files can be output. The payoff matrix can then be used as an input file for additional analyses. In addition, GATES can generate a source code file using the integer programming procedure, PROC LP, from the operations research software available in the Statistical Analysis System (SAS/OR) software. PROC LP is useful for analyzing linear programming problems too large for a personal computer. In cases where, due to the presence of side constraints that are too restrictive for the netflow structure of GATES to resolve as an optimal solution, the integer structure of the PROC LP algorithm will produce an optimal solution. When error messages occur with Optimal LP in GATES or when there is a question about optimality of the assignment, producing the PROC LP source code and executing the assignment with SAS/OR is a good check.

Detailed Report

The Detailed Report File contains specific information for each person assigned as well as unassigned people and jobs. GATES displays the subject number (sequence number), BMT graduation date, specialty (AFSC) assignment, training class start date and any selected fields or MOMs for each assignment. Wonder or another spreadsheet, can be used to perform computations based on the assignments or data fields. A detailed file, DETAIL.OUT, is automatically produced with each execution of GATES. To provide a unique name for this report select Detail File from the Run - pull down menu.

Summary Report

The Summary File contains summary statistics of the final assignments and MOMs. SUMMARY.OUT is produced with each execution of GATES. Other information contained in the Summary File includes % of total people assigned; % of total jobs assigned; % of total jobs by AFS filled; and % of jobs filled by minorities, high quality, males, and females. To provide a unique name for the summary report select Summary File from the Run pull down menu. If a payoff or objective function was used (AF Payoff, User Payoff, or Optimal (LP)), the sum, average and variance of the payoff(s) for each step will be displayed. In every simulation, the total, average, and variance for each MOM is computed. A word processor should be used to view this file.

The formula used for variance (s^2) is:

$$s^2 = \frac{\sum_{i=1}^{N} (x_i - \bar{x})^2}{N-1}$$

where:
x_i = the payoff for person i to a job
$\bar{x}$ = the average of the payoffs
N = the total number of payoffs for all people to all jobs

Ancillary Files

Previous Match

Previous Match allows the user to evaluate different or additional MOMs or data fields associated with an assignment without re-executing the assignment. Before executing a Previous Match, select the additional MOM (or data fields) from the Run - Select MOMs menu. After clicking Run - Previous Match, GATES prompts for the Detailed filename from a previous run. GATES will then compute the additional MOMs

and append these results to the Detailed and Summary files. Go to the Run - pull down menu to select Previous Match.

Payoff Matrix

The Payoff Matrix file contains each person's payoff corresponding to each job. To create this file, it is assumed that each person is qualified for each job. This file represents the "payoff matrix" for a given objective or payoff function. To create a payoff matrix click the Payoff Matrix option from the Run menu. The matrix is computed using the applicants from the current personnel file for the rows of the matrix, the jobs from the current job file as the columns, and the currently defined payoff or objective function. GATES will then calculate the total payoff for each person - job combination and place this value in the respective cell (or position) in the matrix. If a person does not qualify for a given job, GATES still reports a payoff. Note that the matrix includes Open AI jobs as well as GTEPs. This allows the user to calculate statistics separately for assignments made in the first and second steps of a two-tier strategy. A file called PAYOFF.OUT is produced with an execution of GATES when requested by the user. To provide a unique name for this file, select Payoff Matrix from the Run - pull down menu.

GATES reports summary statistics for the Payoff Matrix in the current Summary Report file. The entire matrix (both GTEP and Open AI assignments) is used in the calculation of the summary information.

The following statistics for the payoff matrix are appended to the (current) Payoff file:

(1) Row sum of squares =

$$\frac{1}{V}\sum_{i=1}^{N}\left(\sum_{j=1}^{V}P_{ij}\right)^2-\frac{1}{NV}\left(\sum_{i=1}^{V}\sum_{j=1}^{N}P_{ij}\right)^2$$

(2) Column sum of squares =

$$\frac{1}{N}\sum_{i=1}^{V}\left(\sum_{j=1}^{N}P_{ij}\right)^2-\frac{1}{NV}\left(\sum_{i=1}^{N}\sum_{j=1}^{V}P_{ij}\right)^2$$

(3) Sum of square due to rows (people) and columns (jobs) interaction. Interaction sum of squares =

$$\sum_{i=1}^{N}\sum_{j=1}^{V}(P_{ij})^2-\frac{1}{V}\sum_{i=1}^{N}\left(\sum_{j=1}^{V}P_{ij}\right)^2-\frac{1}{N}\sum_{i=1}^{V}\left(\sum_{j=1}^{N}P_{ij}\right)^2+\frac{1}{NV}\left(\sum_{i=1}^{N}\sum_{j=1}^{V}P^2{}_{ij}\right)$$

where:
P_{ij} = the "payoff" of person i for job j
N = the number of people
V = the number of jobs

SAS LP Code

The SAS LP Code option under the Run menu creates a sparse data set and source code to run the assignment problem as an integer program using the PROC LP procedure from the operations research (OR) software available in the Statistical Analysis System, SAS/OR (SAS Institute Inc., 1990). The algorithm selected must be a single-tier Optimal LP. The objective function and constraints are taken from the current single-tier Optimal LP algorithm. The current source files are used for the applicants and jobs.

To generate the code and data set,

1. Choose Strategy - One-Step from the menu
2. Click the Optimal (LP) algorithm
3. Build the objective function and constraints
4. Choose the Run - SAS LP Code menu option
5. Select a filename to contain the sparse data set

The destination filenames will be displayed in the main window of GATES (e.g., LP.DAT and LP.SAS). Switch to the SAS/OR program and read the LP.SAS file. If you are using SAS for Windows, click the right mouse button in the Program Editor and choose File - Open - Read File with the left mouse button. Submit the program by typing SUBMIT in the Command window (or press F3 on the keyboard). The assignments will be displayed in the Output window after PROC LP finishes.

The following is an example of a full SAS/OR LP data set which minimizes the objective function and has one constraint. The data set has three people and two jobs

	xP0J0	xP0J1	xP1J0	xP1j1	xP2J0	xP2J1		
Func	<cost>	<cost>	<cost>	<cost>	<cost>	<cost>	min	.
P0	1	1					eq	1
P1			1	1			eq	1
P2					1	1	eq	1
J0	1		1		1		eq	<# seats>
J1		1		1		1	eq	<# seats>
Conl	-.4		.6		.6		eq	0

(with any number of class seats) resulting in six possible assignments (arcs). If person 1 (P0) is the only female, the constraint (Con1) could represent a sixty percent gender goal for job 1 (J0). The sparse data set generated by GATES eliminates any zeros from the matrix reducing the size of the file for most problems. See the SAS/OR User's Guide for more information and examples on using PROC LP.

V. TUTORIAL

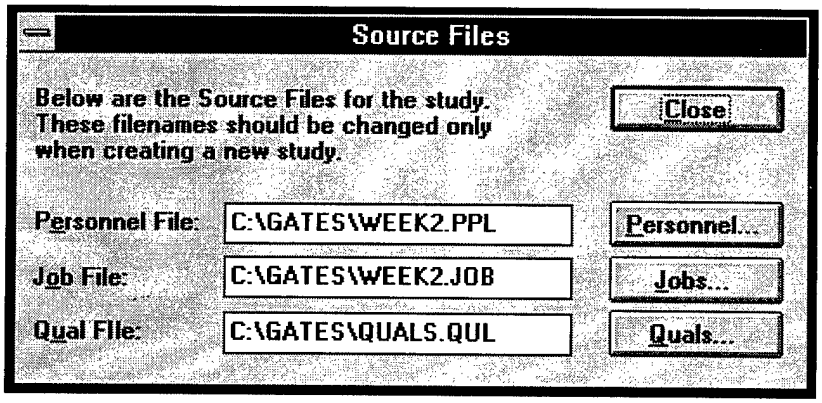
This section is a tutorial for the use of GATES in the design of a classification system including the steps necessary to select input files, simulate a chosen assignment system, and produce and interpret reports. The input files will consist of a week group of people and jobs from the library of accession records in the Air Force. The system design will be a two-tiered strategy with the User Payoff sequential algorithm at the first step and the Optimal LP batch algorithm at the second step. The order of discussion follows the logical sequence in which design choices and issues would be addressed in conducting a classification study. However, most dialog boxes can be addressed in any order thus allowing the user to alter a study specification at any point without restarting or reconfiguring GATES.

1. Selecting the Source Files

Source files contain the applicants and their attributes (Personnel file), training information on job vacancies and class seats available (Job file), and the associated attributes and qualifications for each job (Qualification file). Several data files obtained from actual applicants and accessions documented in the Air Force Master Personnel files are distributed with GATES. In this example Week2 group is used. To use WEEK2.PPL as the current Personnel file, from the Source Files menu choose the Personnel option. Type WEEK2.PPL in the Personnel File text box or highlight the file (in the file list box) and click the OK button. Follow the same procedure for Source Files - Jobs and Source Files - Quals to select WEEK2.JOB and QUALS.QUL.

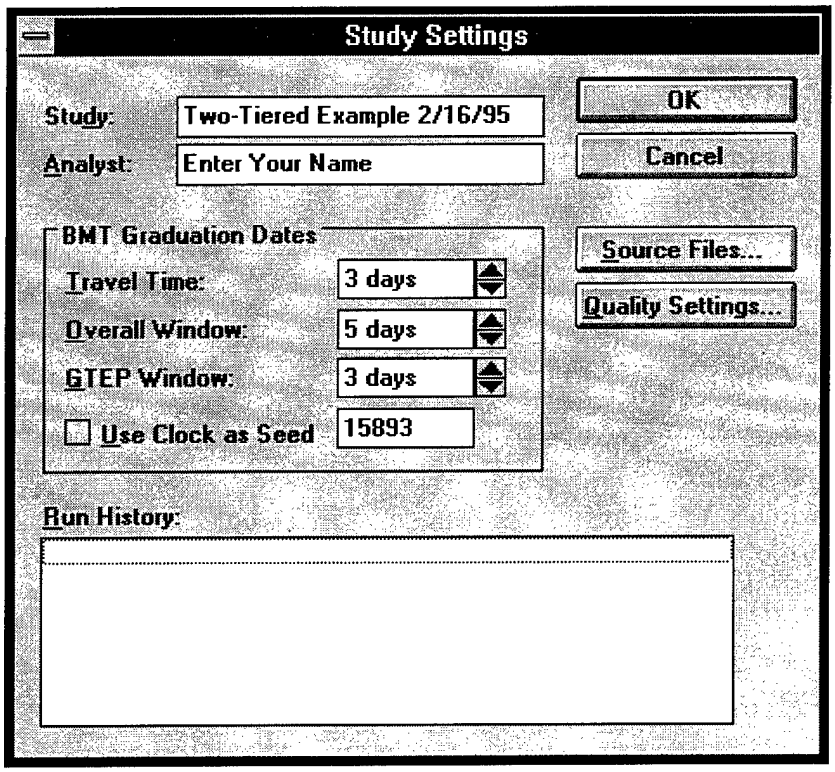
2. View Source Files

To verify that the model is using the correct source files, from the View menu choose the Source Files option and the Source Files dialog box as shown below will appear. The Sources Files dialog box displays the Personnel, Job, and Qualification filenames specified for the current study. If any are incorrect, click the appropriate button to reselect a file.



3. View Study Settings

The study settings control how GATES internally generates several parameters necessary for determining assignments when graduation dates affect the match or when casual time is a MOM, payoff, or objective function. To set these parameters select the View - Settings option from the menu. The following Study Settings dialog box as shown below will appear. Under BMT Graduation Dates, three buttons for controlling BMT Graduation dates appear. Details for these buttons appear in Section II, Study Settings. To increase or decrease these values, use the appropriate spin button (arrows) next to each text box. To set the seed of the random number generator when allocating graduation dates, clear the check mark from the Use Clock as Seed check box and type in a seed of choice. For the tutorial make sure the Travel Time is three (3) days, the Overall Window is five (5) days and the GTEP Window is three (3) days. From the Use Clock as Seed check box, click the mouse and type 15893 in the text box to the right.



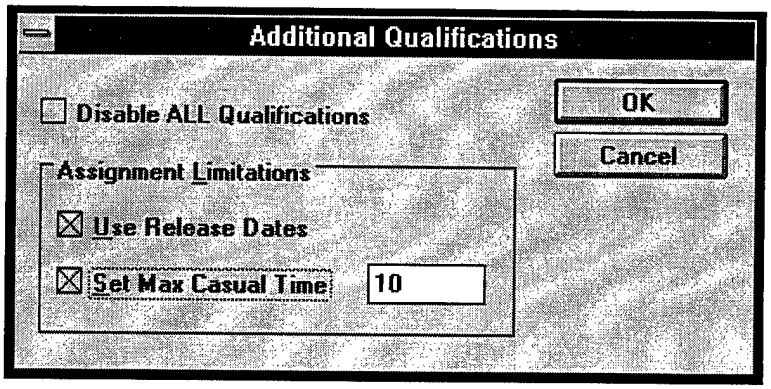
To give the current study a descriptive title, type "Two-Tier Example 2/16/95" in the Study text box. Next, enter the name of the analyst in the Analyst text box.

4. View Additional Qualifications

Besides qualifying each assignment with the appropriate composite cutoff score, GATES allows the user to set two eligibility checks during assignments. The first eligibility check, Use Release Dates, applies to sequential algorithms to disqualify

applicants if their Subject Number is less than the Release Index for a job. The second check sets the maximum casual time allowed for any assignment (determined by subtracting Travel Time plus BMT Graduation Date from Class Start Date).

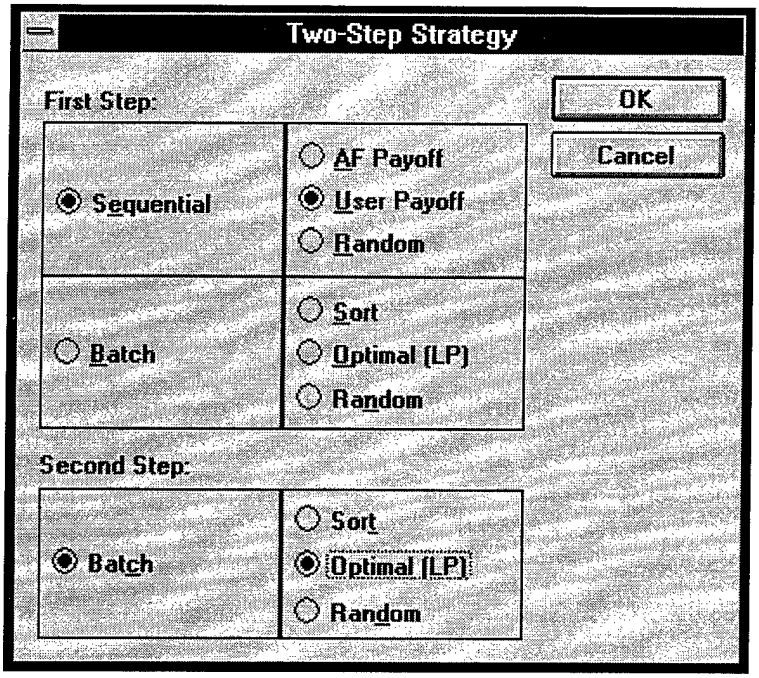
From the View menu select the Qualifications option and the Qualifications dialog box shown below will appear. To activate the Use Release Dates, make sure the check box is marked. For job release dates to work correctly values of the variable ReleaseIndex must be present in the Job File (see Section II, Job Files and Settings). To set 10 days as the maximum casual time, click the Set Max Casual Time check box and enter 10 in the text box to the right. This will disqualify any match where the resulting casual time of the assignment (the applicant's Travel Time plus BMT Graduation Date minus the job's Class Start Date) would be greater than the maximum (10 days).



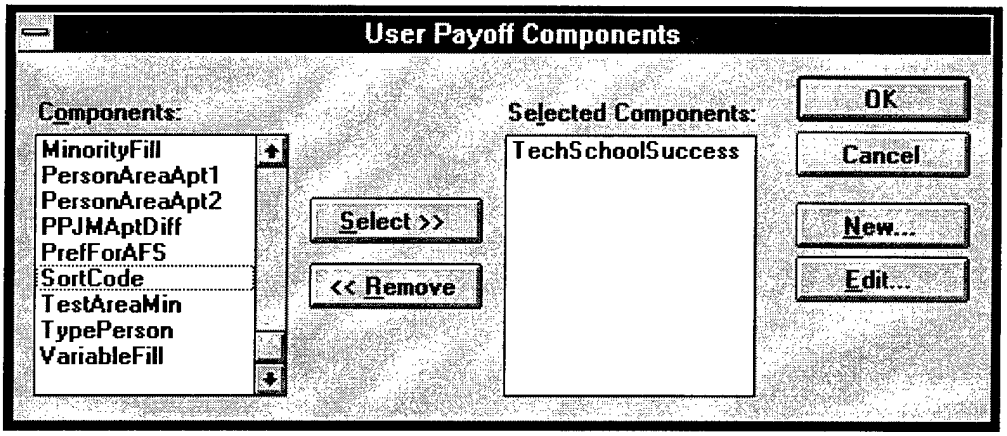
5. Selecting a Two-Tier Strategy

The most important step in GATES is selecting a classification strategy. A two-tier strategy assigns applicants to guaranteed specialties (GTEP) and occupational areas (Open AI) in the first step and then assigns the Open AI recruits from the first step to AFSCs in the second step. A single-tier strategy assigns all the applicants to AFSCs in one step.

To select a two-tier strategy, from the Strategy menu choose the Two-Step option and the Two-Step Strategy dialog box shown below will appear. Our example will show how to setup the User Payoff algorithm in the first step with an Optimal (LP) algorithm in the second. From the Two-Step Strategy dialog box, click the User Payoff radio button in the First Step list box and Optimal (LP) radio button in the Second Step list box. Click the OK button or press <enter> to accept these choices and prompt the parameter dialog boxes for the two selected algorithms.

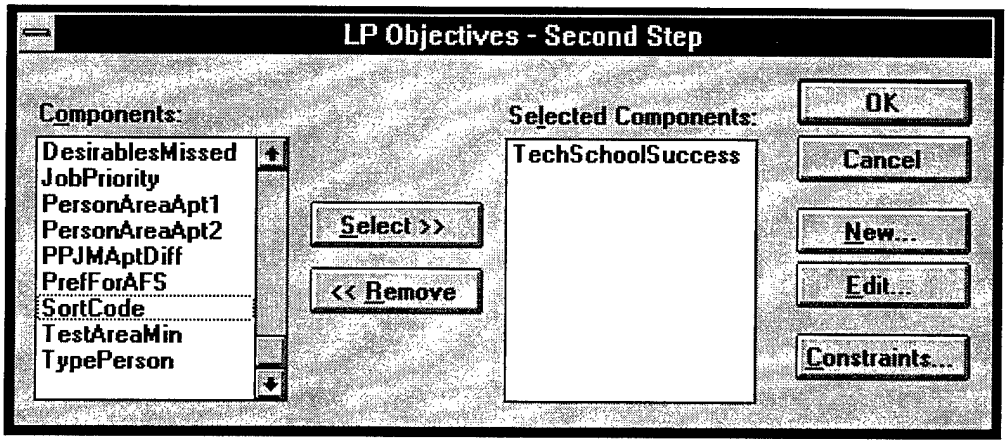


The User Payoff dialog box shown below displays the components available in GATES that can be selected to form the User Payoff payoff function. Highlight TechSchoolSuccess in the Components list box (click the down arrow in the left list box to scroll the functions downward, then place the cursor over TechSchoolSuccess and press the left mouse button). Then click the Select button. This will select the TechSchoolSuccess component as the payoff function. Click OK or press <enter< key to accept this parameter.

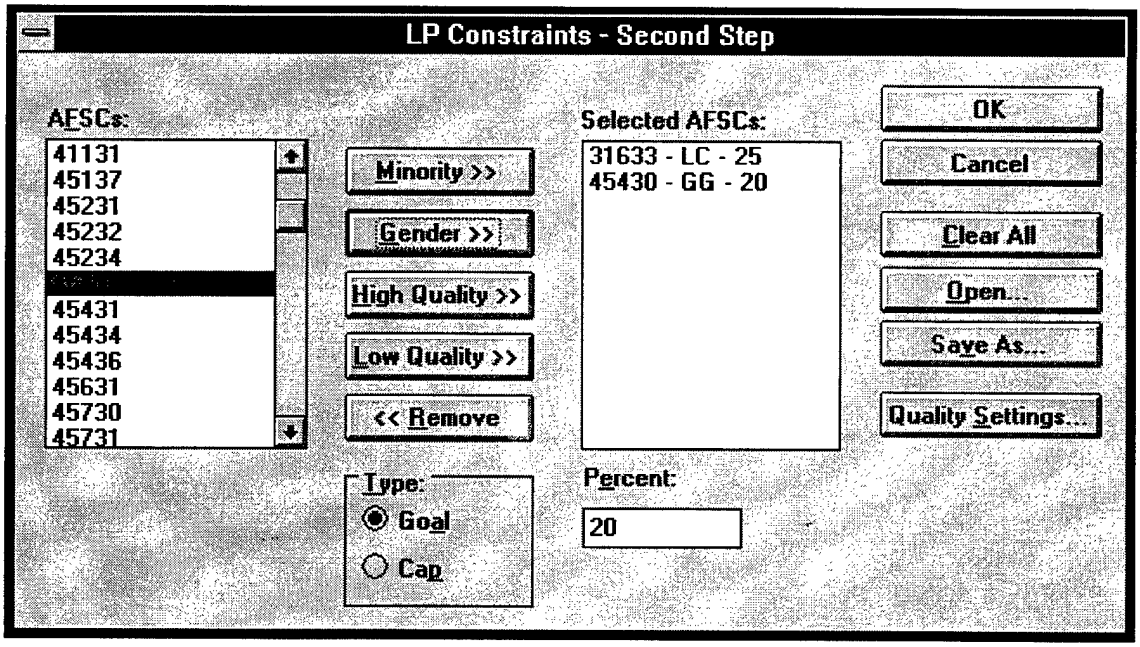


Next, the dialog box, LP Objectives, for the LP algorithm chosen as the assignment algorithm for the second step will appear. Highlight the TechSchoolSuccess component from the Components list box and click the Select button. The right list box should now display the selected component. Click the OK button to accept the objective

function choice. The objective function for the LP is now -1 * TechSchoolSuccess. The dialog box for the LP Objectives screen should appear as shown below.

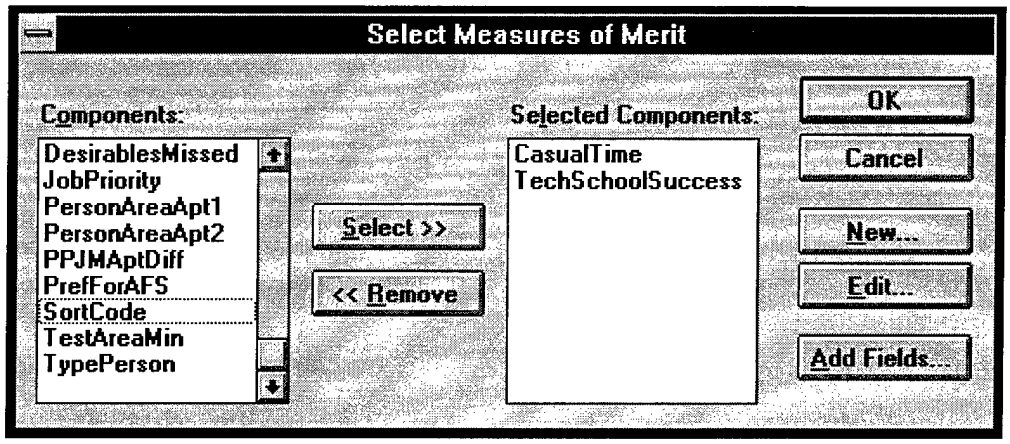


To impose constraints on the LP, click the Constraints button on the right side of the dialog box and the LP Constraints dialog box will appear as shown below. GATES allows two types of constraints, goals or caps, on four variables, minority, gender, high, and low quality. A goal sets the minimum percentage of that type to assign whereas a cap sets the maximum percentage of that type to assign. To set a 20% gender goal for AFSC 45430, highlight 45430 in the AFSCs list box and enter 20 in the Percent text box. Next, click the Gender button which adds the constraint to the Selected AFSCs list box. Now, add a 25% Low Quality cap for AFSC 31633. The two constraints, 45430 - GG - 20.0 and 31633 - LG - 25.0, should both appear in the Selected AFSCs list box. Click the OK button for the constraint dialog box and again for the LP Objectives dialog box to accept all choices and settings. The selected strategy will appear in the main window of GATES.

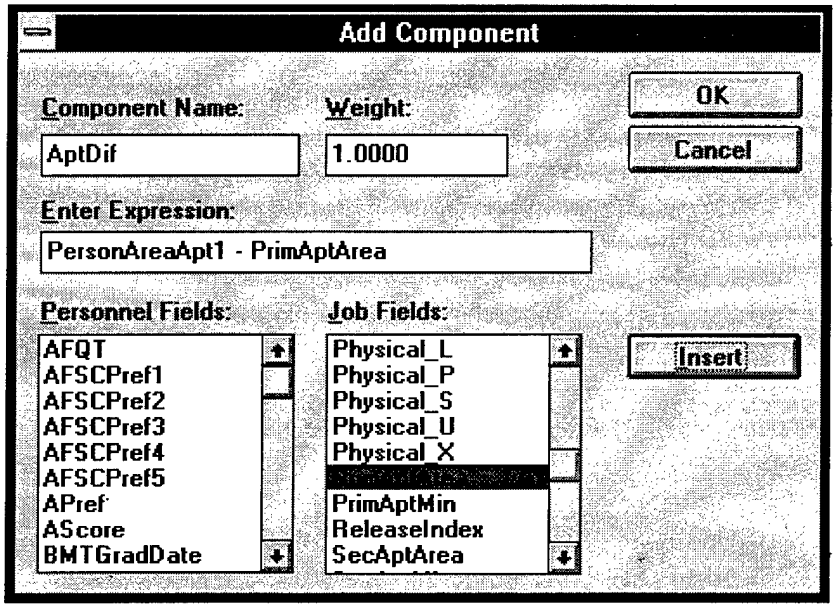


6. Select Measures of Merit (MOMs)

MOMs serve as a quantitative basis for comparing the performance of competing classification systems and algorithms. GATES reports descriptive statistics on selected MOMs for an assignment (or Historical Match) in the Summary Report File. To select a component as a MOM, from the Run menu click the Select MOMs option. The Select Measures of Merit dialog box shown below will appear. As with the LP Objectives dialog box, highlight TechSchoolSuccess and click the Select button. Also select the component Casual Time.

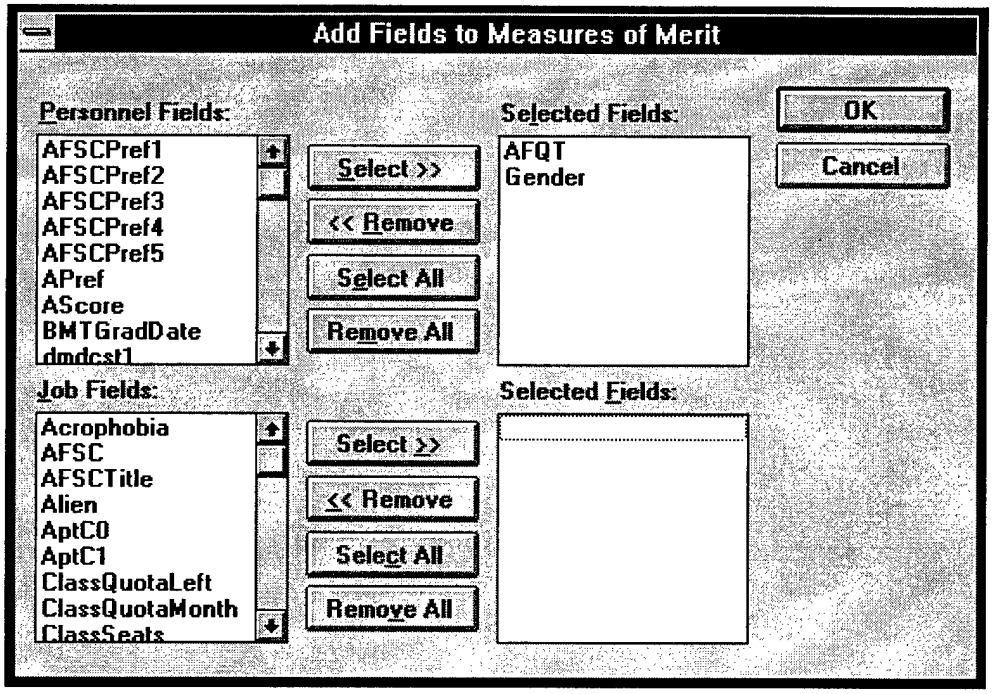


To create a new MOM, click the New button and the Add Component dialog box shown below will appear. An interesting MOM for any assignment might be the difference between the person's aptitude score and the job's standard requirement on the composite for that job.



To create this MOM, first enter a name for the MOM in the Component Name text box of the Add Component dialog box. Next, enter the mathematical expression for the new component in the Enter Expression text box. The new MOM will be called AptDif and the expression will be, PersonAreaApt1 - PrimeAptArea. PersonAreaApt1 is a pre-defined component that appears in the Components list box of the Select Measures of Merit dialog box. It returns the person's score on the composite standard required for a job. PrimeAptArea is a job characteristic that appears in the Job Fields list box of the Add Component dialog box. It returns the minimum score on the composite required for qualification in the job. Click the OK button to accept the specifications for AptDif and return to the Select Measures of Merit dialog box.

To report specific characteristics for a person or job click the Add Fields button of the Select Measures of Merit dialog box and the Add Fields to Measures of Merit dialog box shown below will appear. In the Personnel Fields list box (top left), highlight the AFQT and Gender fields and click the Select button. The two fields should now be displayed in the top right list box. When finished, click the OK button for the Add Fields and Select Measures of Merit dialog boxes to accept all choices.



7. Select the Output Files

The Detailed Report file contains the values for the payoffs, MOMs, and individual person and job characteristics specified for all the assignments made. To select a filename for the Detailed Report, click on the Detailed File option of the Run menu and the Select Detail File dialog box will appear. In the File Name text box enter the filename EXDETAIL.OUT and click OK. The Summary Report file contains

statistics on the requested payoffs, MOMs, and individual characteristics for the assignment. To change the Summary Report filename click on the Summary File option of the Run menu and the Select Summary File dialog box will appear. In the File Name text box type EXSUMM.OUT. Click OK to accept the file.

8. Run Start

To execute GATES click on the Start option from the Run menu. GATES will execute the two-tiered strategy using the selected algorithms and parameters (in this case, User Payoff and Optimal (LP)). An hour glass cursor is shown until the execution is complete. Messages will also appear in the main window of GATES showing the status of the current run. If the wrong source files or algorithms are used, just repeat those (and only those) steps as necessary.

9. Saving a Study

To save a study click on the Save As option from the Study Menu. Type the desired study name in the File Name text box. The selected source files, strategy, settings, payoffs, MOMs, and report file names will all be saved under the given study name. This capability makes rerunning a study or making changes to a study much more convenient.

10. Viewing the Results

When the execution of GATES is complete, a user would want to view the report files of results. The Detailed Report file contains information on payoffs and MOMs for each person's assignment as well as a listing of unassigned people and jobs. The Summary Report file contains summary statistics of the final assignments and MOMs. To view either report file a spreadsheet such as EXCEL may be used. A spreadsheet, Wonder, is distributed with GATES. To view a report file in Wonder simply double-click on the Wonder icon, open the report file by choosing the Open option from the File menu, and type the name of the report file in the File Name text box.

To open the Detailed Report file for this example, choose the Open option from the File menu of the spreadsheet and type EXDETAIL.OUT in the File Name text box. The report will be displayed in the grid of the spreadsheet. Some brief information about the study design appears at the top of the grid. The source files, Detail Report file name, strategy, and constraints are listed followed by information on the assignment of each person in the input personnel file. The first five columns of assignment information contain the subject number of the applicant (Subjectnum from the personnel file), the BMT graduation date, AFSC assignment, class start date (ClassStartDate from the job file), and the step in which the applicant received an AFSC assignment (see example data set below). These first five columns of information are used when running a Previous Match.

Subsequent columns contain information on payoffs, specified MOMs, and data fields selected as additional fields. In this example Payoff 1 and Payoff 2 appear as the payoff values generated in the first and second steps of the specified two-tiered design. An applicant with a value of 1 for step will have a value for Payoff 1 and a zero for Payoff 2. Payoff 1 corresponds to his assignment to an AFSC in the first step. An assignment at the second step is then not possible and indicated by a value of 0 for Payoff 2. An applicant with a 2 for Step will have two payoff values. The first payoff value corresponds to his open area assignment at the first step. The second payoff corresponds to his AFSC assignment at the second step. The negative sign on the second payoff appears as a result of adherence to conventional notation used in linear programming. The solution to an LP is stated as a minimization of the objective function. Since the assignment algorithm at the second step is an LP that is maximizing the objective function the negative sign is used. Information on additional fields selected and MOMs follows the payoff columns. AFQT and Gender were selected as additional fields. Predicted performance at Technical School (TechSchoolSuccess), Casual Time, and AptDif (PersonAreaApt1-PrimeAptArea) were specified as MOMs and follow columns of additional fields information. An excerpt of the first and last lines of EXDETAIL.OUT follows.

Person	**Grad Date**	**AFS**	**Start Date**	**Step**	**Payoff 1**	**Payoff 2**	**AFQT**	**GENDR**
1	3/26/92	98130	3/31/92	1	91.43	0	81	0
2	3/26/92	98130	3/31/92	1	92.0206	0	71	1
3	3/27/92	98130	3/31/92	1	91.667	0	61	1
4	3/30/92	49132	4/3/92	1	95.3547	0	91	0
5	3/28/92	49330	4/1/92	1	96.9928	0	95	1
6	3/31/92	64530	4/6/92	1	93.1797	0	79	1
.....								
84	3/17/92	64531	3/24/92	2	86.7487	-101.8201	80	1
88	4/3/92	81132	4/9/92	1	83.697	0	54	1
93	4/3/92	81132	4/9/92	1	82.1342	0	52	1
11							68	1
16							67	1
.....								
91							76	1
92							50	1
	3	41131	4/13/92					
	3	45234	4/3/92					
.....								
	2	81132	4/9/92					
	1	90232	4/9/92					

The listing of assignment information begins with applicants 1, 2, 3, etc. and ends with applicant 93. A listing of unassigned applicants follows along with values for the additional fields requested (AFQT and Gender). Applicants 11, 16, to applicant 92

comprise the listing of unassigned personnel. Finally, a listing of unfilled jobs from AFSC 41131 to AFSC 90232 completes the Detail Report.

The Summary Report file, EXSUMM.OUT, can be opened into a spreadsheet in the same manner as the Detail Report file. A word processor may be also be used to display this report file. The tab settings will need to be changed for the columns to align correctly if a word processor is used. Information in the Summary Report is formatted into three sections (see the example report below). The first section lists the source files used in the study, the name of the Detailed Report, the strategy and algorithms used, the payoff or objective functions, constraints, and percentages of personnel assigned and unassigned. Also in the first section are the number of personnel assigned at each step and percentages of jobs assigned and unassigned. For the example, out of 93 personnel, 56 were assigned or 60.22% and 37 were unassigned or 39.78%. Thirty-five personnel were assigned at step one and 21 assigned at step two. Many personnel are left unassigned in this example as a casual time limit of 10 days was specified as one of the study settings. Imposing a limit on casual time for assignments can have a dramatic effect on the ability of an algorithm to accomplish assignments. An examination of the listing of unassigned personnel from the Detailed Report shows that the User Payoff sequential algorithm at the first step is unable to assign increasing numbers of personnel as it processes down through the personnel file.

The second section of results reported in the Summary Report are percentages on assignments grouped by AFSC. Percentages listed include: percent of the personnel file assigned to the AFSC, percent of seats (jobs) filled represented by that AFSC in the job file, percent seats not filled, percent of those personnel assigned to the AFSC that are female, percent that are minority, percent of those personnel assigned to the AFSC that are high quality, and percent that are low quality. Quality is defined according to AFQT values specified as study settings. A portion of the Summary Report File for this example follows.

Person File:	C:\GATES\WEEK2.PPL
Job File:	C:\GATES\WEEK2.JOB
Qualification File:	C:\GATES\QUALS.QUL
Detailed Output File:	C:\GATES\EXDETAIL.OUT

Two Step Strategy:

1st: User Payoff
1*TechSchoolSuccess

2nd: Optimal (LP)
-1*TechSchoolSuccess
2 Constraints:

Low Quality Cap	31633	25%
Gender Goal	45430	20%

Out of 93 People
56 (60.2151%) Assigned
37 (39.7849%) Unassigned

Number of People Assigned to AFSC's:
1st Step: 35
2nd Step: 21

Out of 93 Seats,
56 (60.2151%) Filled
37 (39.7849%) Not Filled

AFSC	% Assigned People	% Seats Filled	% Seats Not Filled	% Female	%Minority
30434	1.79%	100% (1)	0% (0)	0% (0)	0% (0)
31633	3.57%	100% (2)	0% (0)	0% (0)	0% (0)
36234	1.79%	100% (1)	0% (0)	0% (0)	0% (0)
.....					
99604	3.57%	100% (2)	0% (0)	0% (0)	50% (1)

AFSC	% High Quality	% Low Quality
30434	100% (1)	0% (0)
31633	100% (2)	0% (0)
36234	100% (1)	0% (0)
.....		
99604	50% (1)	0% (0)

Summary Statistics for the Assignment (Step 1):
Sum of the Payoffs for the Assignment 3771.73
Mean of the Payoffs for the Assignment 89.8524
Variance of the Payoffs for the Assignment 17.4274

Summary of Statistics for the Assignment (Step 2):
Sum of the Payoffs for the Assignment -1962.127
Mean of the Payoffs for the Assignment -72.538
Variance of the Payoffs for the Assignment 272.615

Constraint Violations:
Constraint 1 (31633 - LG - 25%) violated. Only 0 assigned out of 2 total assignments for the AFSC.
Constraint 2 (45430 - GG - 20%) violated. Only 0 assigned out of 1 total assignments for the AFSC.

Individual assignments of people to jobs are not necessarily predicated upon the value of a reported Measure of Merit (MOM) unless that MOM has been designated as the payoff computed by a chosen allocation strategy.

Summary Statistics for Measures of Merit of the Assignment Matrix:

TechSchoolSuccess

Sum:	5073.56
Mean:	90.5994
Variance:	22.6358

CasualTime

Sum:	264
Mean:	4.71429
Variance:	14.1351

AptDif

1*(PersonAreaApt1-PrimAptMin)

Sum:	1617
Mean:	28.4286
Variance:	149.7114

The last section of the report contains statistics on the assignment algorithms and MOMs specified. If the constraints were violated a message is included in this section. Statistics reported include sum, mean, and variance of the payoffs for assignments for each of the assignment algorithms used followed by similar statistics on all specified MOMs. The sequential User Payoff algorithm accomplished a mean of payoffs of 89.8524. This mean includes the assignments to occupational area in step one. The LP in the second step accomplished a mean payoff of -72.538. This mean includes the zero payoffs for those personnel assigned in step one. The payoff statistics are not particularly useful, and it is recommended that all payoff functions and objective functions be specified as MOMs. The statistics on payoffs are followed by statistics on MOMs. TechSchoolSuccess is specified as the first MOM and has a mean of 90.5994. The MOM includes assignments to AFSC accomplished at both steps. In other words, the assignments to occupational area in the first step and the zero payoffs at the second step corresponding to personnel assigned to AFSC at the first step are not included in this statistic. Then, the mean for the MOM, TechSchoolSuccess, is the accurate indicator of performance for the strategy. Casual time has a mean of 4.7143 and AptDif a mean of 28.4286. The mean value of AptDif indicates that on average the assignments accomplished matched personnel to jobs such that the aptitude of the person assigned exceeded the job qualification score by 28 points.

Examination of the report files using a spreadsheet statistical function capability can reveal further descriptive information about the MOMs. For instance, the distributional properties of payoffs and MOMs might be of interest.

VI. CONCLUSION

The goal of personnel classification research is to develop methods of matching people to jobs that reflect evolving organizational policy and increase the efficiency and effectiveness of person-to-job matches. GATES provides a user friendly, efficient platform from which the research scientist and personnel manager may quantitatively evaluate operational S&C systems. Competing S&C system designs may then be compared with operational designs and potential gains in classification benefits observed. S&C system factors available for comparison within GATES include alternative applicant population characteristics, new or experimental MOMs, various occupational specialty clusterings, as well as competing system designs and classification algorithms.

GATES also facilitates theoretical research using empirically generated data on varying rejection rates, people-to-job ratios, and varying validities and intercorrelation patterns among estimates of classification utility. GATES can be applied to S&C study design and evaluation at any of the United States Military Services or the International Military Services, as well as the evaluation of issues of supply/demand or product flow in industry and academia.

The Services are being required to do more with less under conditions of changing mission structures, increased job demands, and a decreasing supply of quality applicants. Goals must often be achieved under severe constraints. S&C operational procedures often serve conflicting goals, performance vs costs, casual time and job fill vs performance and job satisfaction, etc. Many of these conflicts have the potential to affect a recruit's decision to join the military. GATES evaluates and compares alternative payoff/objective functions reflecting adjustments to S&C organizational policy necessary to accommodate the changing job/applicant environment.

While the present problem of assigning large numbers of personnel to their many jobs has motivated the Military Services to rely on some of the products of their personnel classification research program, it is expected that future technological, economic, and socio-political changes will greatly increase the criticality of this type of research. Changing conditions are expected to reduce the supply of qualified individuals while the demand for these workers by the Military Services will increase. Assignment systems of the future will have to overcome this scarcity of qualified personnel by assigning personnel to jobs that make the best use of each individual's skills and abilities. Additionally, future personnel assignment systems will be required to operate in conformity with public policies and societal focus on "equity" and "fairness" issues. Different classification methods exist which provide opportunities for enabling the Services to make the most of available personnel resources. Improved classification systems are a far cheaper alternative for increasing job performance than more expensive methods such as increased training or resource-intensive recruiting/testing programs.

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APPENDIX A: FORMAT FILES

The format files describe the fields and field types for the Personnel (people.fmt), Job (jobs.fmt), and Qualification (quals.fmt) files. Use a text editor such as EDIT.COM or Notepad to edit these files. There are four types of fields used in GATES, I = Integer, F = Float, S = String, and D = Date. With the String field type, a maximum length must also be entered. The user should only add fields to files (some aspects of GATES will not work correctly if fields are deleted or changed as well as old Source files would then be incompatible). When commenting a field, be sure and precede the comment with a semicolon. Remember that field names are case sensitive.

To add an integer field MyField1 to the Personnel file, append the statement "MyField1, I" to the People.fmt file. This field will now be recognized by the model and can be used in components, functions, or Measures of Merit. Remember to enter the data in the Personnel file (the model will fill empty fields with zeros). A listing of all the fields in the format files follows.

People.fmt

Field Name, type, length	Field Comment
Subjectnum,I	used as a reference for reporting
Gender,I	0 = female
Race,I	0 = non-minority
MScore,I	Mechanical Score
AScore,I	Administrative Score
GScore,I	General Score
EScore,I	Electronic Score
MPref,I	MAGE area prefs (0-9)
APref,I	
GPref,I	
EPref,I	
HSGrad,I	1 if graduated from High School
HSAlgebra,I	1 if HS course was taken : Algebra
HSBiology,I	1 if HS course was taken : Biology
HSChemistry,I	1 if HS course was taken : Chemistry
HSEnglish,I	1 if HS course was taken : English
HSGeometry,I	1 if HS course was taken : Geometry
HSPhysics,I	1 if HS course was taken : Physics
HSTrig,I	1 if HS course was taken : Trigonometry
AFQT,I	AFQT Score
dmdcst 1, I	ASVAB Subtest Scores - General Science

Field Name, type, length	Field Comment
dmdcst 2, I	Arithmetic Reasoning
dmdcst 3, I	Word Knowledge
dmdcst 4, I	Paragraph Comprehension
dmdcst 5, I	Numerical Operations
dmdcst 6, I	Coding Speed
dmdcst 7, I	Auto & Shop Information
dmdcst 8, I	Math Knowledge
dmdcst 9, I	Mech Comprehension
dmdcst 10, I	Electronic Information
dmdcst 11, I	Combination of WK & PC
AFSCPref1,S,10	Pace Preferences (AFSs)
AFSCPref2,S,10	
AFSCPref3,S,10	
AFSCPref4,S,10	
AFSCPref5,S,10	
Pulhes_P,I	Physical Stamina
Pulhes_U,I	Upper Extremities
Pulhes_L,I	Lower Extremities
Pulhes_H,I	Hearing
Pulhes_E,I	Eyes
Pulhes_S,I	Psychiatric
Pulhes_X,S,1	X Factor (strength)
HSType,S,1	Typing in High School
DriverLicense,I	Has a Driver's License
PAcrophobia,I	Has Acrophobia
PAlien,I	Is an Alien
PColorVision,I	Has Color Vision
PDepthPercep,I	Has Depth Perception
PFingers,I	Has full use of fingers
PPeaceCorps,I	In Peace Corps
PSpeachImp,I	Has a Speech Impairment
BMTGradDate,D	BMT Graduation Date
HistAFSC,S,10	Historical AFSC assignment

Jobs.fmt

Field Name, type, length	Field Comment
AFSC,S,10	
ClassStartDate,D	Starting Date of Class
ClassSeats,I	Total number of class seats

Field Name, type, length	Field Comment
GTEP,I	Number of GTEP class seats
PACEJobPriority,I	Priority of class (PACE)
ReleaseIndex,I	Used to simulate Release Dates (Times)

Quals.fmt

Field Name, type, length	Field Comment
AFSC,S,10	
AFSCTitle,S,40	Description of AFS
PrimAptArea,S,5	Primary Aptitude Area
PrimAptMin,I	Primary Aptitude Minimum
SecAptReq,S,1	Secondary Aptitude Requirement
SecAptArea,S,5	Secondary Aptitude Area
SecAptMin,I	Secondary Aptitude Minimum
ColMean,F	Column Mean (DI)
AptC0,F	Aptitude Difficulty C0
AptC1,F	Aptitude Difficulty C1
JobDiff,F	Job difficulty (Y11_D)
TechC0,F	Tech School Success weights
TechMech,F	
TechAdmin,F	
TechGen,F	
TechElec,F	
TechAFQT,F	
TechAlg,F	
TechBio,F	
TechChem,F	
TechEng,F	
TechGeom,F	
TechPhys,F	
TechTrig,F	
TechHSGrad,F	
VarFillK,F	Variable Fill
MinFillG,F	Minority Fill
EducLevel,I	Education Level
HSReqAlg,I	High School Class Requirements
HSReqBio,I	
HSReqChem,I	
HSReqEng,I	
HSReqGeom,I	

Field Name, type, length	Field Comment
HSReqPhy,I	
HSReqTrig,I	
Physical_P,I	PULHESX Requirements
Physical_U,I	PULHESX Requirements
Physical_L,I	PULHESX Requirements
Physical_H,I	PULHESX Requirements
Physical_E,I	PULHESX Requirements
Physical_S,I	PULHESX Requirements
Physical_X,S,1	PULHESX Requirements
Typing,I	Typing Requirement
DriverLis,I	Requires Drivers License
Acrophobia,I	Cannot have Acrophobia
Alien,I	Cannot be an Alien
ColorVision,I	Must have color vision
DepthPercept,I	Must have Depth Perception
UseFingers,I	Must have full use of fingers
PeaceCorps,I	Cannot have been in Peace Corps
SpeechClr,I	Must have clear speech
ClassQuotaMonth,I	Starting total quota for month
ClassQuotaLeft,I	Starting quota left for month
MinorityAssign,I	Starting number of minority assigned
TestStdArea,S,5	Third Aptitude Area (not a qualification)
TestStdMin,I	Third Min (not a qualification)

APPENDIX B: DEVELOPMENT OF THE AF PAYOFF FUNCTION

The AF Payoff function used in GATES was developed at the Air Force Human Resources Laboratory in the 1970s (AFHRL, now the Human Resources Directorate, Armstrong Laboratory, AL/HR). The following paragraphs attempt to document the history of the development of the Air Force S&C system as well as the AF Payoff function.

In the early 1960's a two-phased S&C system was in operation in the Air Force. Phase I occurred at the recruiting station. Recruiters classified recruits into one of four Air Force occupational areas based on their aptitudes and interests. Those areas were and remain today: Mechanical, Administrative, General, and Electronic, commonly referred to by their acronym MAGE. This MAGE assignment took the form of a binding contract between the recruit and the Air Force. The contract promised the recruit a job within the assigned area. Phase II occurred at basic training. A recruit was assigned by a counselor into a specific job, Air Force Specialty (AFS), within the contracted MAGE area. Classification was accomplished by hand one-at-a-time. Recruits were matched to AFS technical training class seats posted as weekly technical school quotas. Problems with this system at basic training fell into two categories: 1) information on recruits gained through interviews with recruiters and counselors was inadequate, and 2) recruits were mismatched to AFSs (class seats) based on aptitudes and interests.

In the mid 1960's a computerized classification system called the Selective Qualification Airmen Recruiting System (SQUARS) was developed to relieve the data and mismatching problems identified at basic training. Implementation of SQUARS occurred in three steps. First automated procedures for collecting data were implemented in 1965. In 1967 a computerized classification subsystem based on a near optimal classification algorithm called the Decision Index or DI (Ward, 1959) was implemented. The DI adjusted an individual's payoff for a job relative to an estimated average payoff of his/her peers competing for that same job. In this way sequential assignments were made to mimic optimal batch assignments. The third step occurred in 1970. The DI was replaced by a batch, prioritized, sort process developed by Air Training Command (ATC now Air Education and Training Command, AETC) named the Processing and Classification of Enlistees (PACE) system (Pina et al., 1988). This process is a non-optimal assignment algorithm that remains operational today at the 394th Personnel Processing Squadron, Lackland AFB.

In the early 1970's attention turned to S&C at recruiting stations. An Air Force team reviewed the recruiting process and recommended the following: the Air Force, in order to compete with industry in a no draft environment, would need to 1) guarantee jobs and offer delayed enlistment options, 2) take advantage of increased computer capability, and 3) establish a central job bank with job release and quota data. The Accession Control Center (ACC) was established at Randolph AFB to meet these objectives. ACC was tasked to provide: 1) automated accounting for recruiting objectives, 2) centralized control of recruiting goals and quotas, 3) automated process for matching individual qualifications and performance data with

job requirements, and 4) daily recruiting status information for management decision making. The Air Force Military Personnel Center (AFMPC) and ATC developed the Procurement Management Information System (PROMIS) to meet ACC's objectives. The system provided for direct contact via phone lines between field recruiters and the ACC. If an AFS was available, it could be reserved for the applicant. PROMIS had several problems: 1) interaction time between ACC and the recruiter was too long, 2) the recruit/AFS match was non-optimal, and 3) job quotas were not immediately available to the recruiter (Ward, Haney, Hendrix, & Pina, 1978).

In the mid 1970's the Air Force Human Resources Laboratory, AFMPC and Headquarters Recruiting Service at Randolph AFB developed a computer based person-job-match (PJM) subsystem to improve the allocation of recruits to AFSs within the PROMIS system. The development of the PJM subsystem required that recruits be classified to jobs within the goals and constraints established by the Air Force. Air Force classification policy was first established and then translated into a mathematical function to produce numerical values expressing the relative worth of assigning a particular recruit to a particular AFS. These values were called payoffs and the process by which the payoff function was developed was later generalized into a decision modeling technique called policy specifying (Ward, 1977). The payoff function developed included components that compared a recruits aptitude to the difficulty of a job for which he/she was being considered. Other components included a measure of predicted success at technical training, a component that adjusted the weight on a job depending on the job's priority and rate of fill, a measure that reflected a recruit's preference for a job, and a minority fill rate component pertinent to jobs sensitive to minority representation. The Decision Index used in SQUARS in the 1960's was imposed on generated payoffs thereby adjusting the payoffs so as to mimic as closely as possible an optimal assignment. The PROMIS system remained a two-phased S&C system with the DI being applied at Phase I, the recruiting station. Approximately 45 percent of all recruits received their job assignment at the recruiting station. The remaining 55 percent were accessed into one of the MAGE areas and received their final AFS assignment at Lackland AFB during basic training. The assignment system used at Lackland remained the non-optimal, batch, sort process, PACE developed in 1970. In November 1976 the new PROMIS system became operational.[1] Counselors at the Armed Forces Entrance Examining Stations (AFEES, now Military Entrance Processing Stations, MEPS) were linked by remote terminals to a main-frame at AFMPC, Randolph AFB. The system which included the PJM subsystem was named the Advanced Personnel Data System's Procurement Management Information System (APDS-PROMIS) or commonly just PROMIS. The system was designed to process non-prior service, enlisted recruits from the time they become interested in the Air Force to the time they entered Basic Military Training. See Armstrong Laboratory Technical Report AFHRL-TR-79-29, "Pre-Enlistment Person-Job Match System", by Hendrix, Ward, Pina, and Haney (1979) for more details of the definitions of parameters, restrictions, variables, and components of the PJM subsystem of PROMIS.

[1] Readers should note that the PJM subsystem of PROMIS is no longer used operationally. If interested, they may contact Headquarters Recruiting Service for information on current classification procedures as well as on other changes in procedures which may have occurred since 1976.

APPENDIX C: PROCESSING AND CLASSIFICATION OF ENLISTEES (PACE) EXAMPLE

The Processing and Classification of Enlistees (PACE) classification process is a post-enlistment batch process which makes assignments of recruits to Air Force specialties. The classification algorithm is a sorting process. PACE takes those trainees given an open Aptitude Area assignment at the MEPS and gives them a specialty assignment. PACE also checks all GTEP assignments to ensure that the trainee remains qualified and that the class seat is still available. In the past PACE was run once a week during Basic Military Training for all trainees in their 12th through 16th day of training at Lackland AFB. Such groups of airmen are called "week groups". Recently, procedures have changed such that PACE is run twice a week for each aptitude area (M, A, G, and E). In the first run, only those trainees who are difficult to place in jobs are considered. These are trainees who qualify for only a few jobs because they have a low aptitude score in their area, they do not have a driver's license, or they are not a citizen. The first group also includes GTEP trainees who are given their guaranteed jobs before anyone else is assigned to a job. Once the hard-to-place group has been considered, the remainder of the trainees with open enlistments in the area are processed by the sorting algorithm. In addition, gender was dropped from the sorting order when the majority of jobs were opened to women. See Armstrong Laboratory Technical Paper AFHRL-TP-87-41, "Processing and Classification of Enlistees (PACE) System Payoff Algorithm Development", by Emerson, Pina, Leighton, and Cummings for more details of the definitions of parameters, restrictions, variables and priorities for the remarks that follow.

PACE is run twice a week for each of the MAGE areas (a total of eight times). A cutoff score in each MAGE area is used to divide the Open AI trainees into two groups. The "low" group and GTEPs are assigned to jobs in the first run followed by the second run placing the "high" group into job assignments. Within each group, a record is generated for each training class for which the trainee qualifies. Each record is then assigned a Sort Sequence Code according to the following table:

01	GTEPs
02	Priority 1 and 2 volunteers
03	Priority 1 and 2 nonvolunteers
04	Priority 3 tru 7 volunteers
05	Priority 3 tru 7 nonvolunteers
06	Priority 8 and 9 volunteers
07	Priority 8 and 9 nonvolunteers.

Priority is a number 1-9 given to each training class that quantifies relative fill priority among the classes and a trainee is a volunteer when the AFS corresponding to the training class is one of the trainee's top 5 job preferences.

For each PACE assignment run, the information on a recruit is combined with job information such that there is a separate record for each of the jobs for which the recruit qualifies containing both information on the recruit and the job. The records are then sorted in the following sequence and order:

Sort Sequence Code	ascending
Priority	ascending
Type Person	ascending
Assessment Rating	ascending
AFSC Aptitude Minimum	descending
Trainee's Aptitude Score	descending
Preference of AFS 1-5 (Qual code 1)	ascending
AFSC Match (Qual code 2)	descending
Desirable Missed (Qual code 3)	ascending
Trainee's second aptitude score	ascending

PACE then assigns the first record in the sorted sequence. If a record contains an assigned trainee or a training class which is full, the record is ignored.

PACE Example

The following short example serves to illustrate the PACE assignment algorithm. A personnel file of four trainees is being considered for assignment to four AFSs, two AFSs (47233, 99604) with two class seats each and two AFSs (36131, 55131) with one class seat each. Assume all GTEPs have already been assigned and every trainee graduates from BMT in time to meet the casual time restriction necessary to be eligible to fill each available class.

Personnel (Trainee) Data Set:

Trainee	Type	Rating	M	Pref 1	Pref 2	Pref 3	Pref 4	Pref 5
1	0	99	55					
2	0	99	47	55131	99604			
3	0	99	94	47233				
4	0	99	60	36131				

Job (AFS) Data Set:

Class	Seats	AFSC	Area	Min	2nd Area	2nd Min	Priority
A	1	47233	M	51			1
B	1	47233	M	51			2
C	1	36131	M	57			3
D	1	55131	M	45			3
E	2	99604	M	32			9

PACE combines personnel and job data into a single qualification data set. PACE determines the jobs for which the individual qualifies and forms a single record for each Technical Training class available for that job. Each record then contains data on a trainee, an AFS for which the trainee qualifies, Sort Sequence Code, and a 3 digit Qual Code for each Class for each AFS for which a Trainee is qualified. In combining the above personnel and job data sets it has been assumed that all trainees meet all desirables for each AFS and that assessment rating is not needed for any AFS.

Qualification Data Set:

Trainee	Class	Sort Code	3 digit Qual Code
1	A	03	950
1	B	03	950
1	D	05	950
1	E	07	950
2	D	04	150
2	E	06	250
3	A	02	150
3	B	02	150
3	C	05	950
3	D	05	950
3	E	07	950
4	A	03	950
4	B	03	950
4	C	04	150
4	D	05	950
4	E	07	950

After sorting according to the PACE algorithm, the records will appear in the following sequence.

Sorted Qualification Data Set:

Trainee	Class	Sort Code	Priority	Rating	AFS MAGE	Trainee MAGE	Qual Code
3	A	02	1	99	51	94	150
3	B	02	2	99	51	94	150
4	A	03	1	99	51	60	950
1	A	03	1	99	51	55	950
4	B	03	2	99	51	60	950
1	B	03	2	99	51	55	950
4	C	04	3	99	57	60	150
2	D	04	3	99	45	47	150
3	C	05	3	99	57	94	950
3	D	05	3	99	45	94	950

Trainee	Class	Sort Code	Priority	Rating	AFS MAGE	Trainee MAGE	Qual Code
4	D	05	3	99	45	60	950
1	D	05	3	99	45	55	950
2	E	06	9	99	32	47	250
3	E	07	9	99	32	94	950
4	E	07	9	99	32	60	950
1	E	07	9	99	32	55	950

The following assignments result:

Trainee 3 to class A (AFS 47233)
Trainee 4 to class B (AFS 47233)
Trainee 2 to class D (AFS 55131)
Trainee 1 to class E (AFS 99604).

APPENDIX D: PRE-DEFINED FUNCTIONS

Pre-existing Components

This appendix is a reference for the Pre-Defined (or pre-built) components in GATES. The user can either use these components directly or create new components using pre-existing components as sub-components. A list of all Pre-Defined components and their definitions follows. The appendix closes with some additional remarks and examples for creating completely new components based on the fields in the Personnel, Job, or Qualification files.

AFSC Aptitude Minimum

Returns the aptitude minimum score of the job. For example, if the job requirement is an E64, the AFSC aptitude minimum is 64.

In GATES, the function can be used by activating:
PrimAptMin

AFSC Match

Returns the number of digits in the AFSC matching the recruit's preferences. For example, if one of the recruit's 5 job preferences is 11230 and the AFSC of the job being filled is 11233, AFSC Match would return 4. To duplicate PACE, use descending order. Note the model considers any match where PACE only considers 5 and 6 digit matches.

Aptitude-Difficulty

This function relates the Job Difficulty score with the area score of the applicant. See (Hendrix et al., 1979) for a complete definition of this function.

In GATES, the function can be reproduced (without the optional component) as:

AptC0 + AptC1 * (AptAreaScore - 99)

Area Preference

Area Preference takes into account the preference a recruit has for an aptitude area. The recruit rates the four MAGE areas between 0 and 9. Area Preference is the weight of the job's Area Preference divided by the sum of all four area weights.

In GATES, the function can be reproduced as:

AreaPref / (MPref + APref + GPref + EPref)

Casual Time

Returns the number of days between the Class Start Date and the BMT Graduation date minus Travel or Processing time.

In GATES, the function can be reproduced as:

ClassStartDate - BMTGradDate - Travel Time

Desirables Missed

Returns the number of desirables (defined as the number of high school courses desired) the recruit is missing. For each AFS, the Qualification File identifies which high school courses the job requires (out of a possible 8). Desirables Missed matches this requirement to the recruit and returns the number of courses not taken.

Job Priority

Returns the priority of the job as given by the user in the Job file. In GATES, the function can be reproduced as: PACEJobPriority.

Minority Fill

Minority Fill takes into account the number of minorities currently in an AFS with a pre-defined minority goal. This function only has meaning for sequential algorithms where the minority ratio changes after every assignment and thus producing a different score. See Hendrix et al. (1979) for a complete definition of this function.

Person Aptitude Area 1

Returns the aptitude score of the applicant in the given job's area. To duplicate PACE, use descending order giving preference to higher aptitude recruits.

In GATES, the function can be reproduced as:

AptAreaScore

Person Aptitude Area 2

Returns the aptitude score of the applicant in the given job's optional area. To duplicate PACE, use ascending order.

PPJM Aptitude-Difficulty

Returns the PPJM Aptitude-Difficulty component for a given applicant and AFSC. The function is developed in Pina et al. (1987).

In GATES, the function can be reproduced as:

Max((35 + .3636 * (AptAreaScore - 95)
+ .05417 * (AptMin - 40) ^ 2
+ .00001136 * (AptAreaScore - 95) * (AptMin - 40) ^ 3
+ .0009848 * (AptAreaScore - 95) * (AptMin - 40) ^ 2
- .0006019 * (AptMin - 40) ^ 3), 0)

Preference for AFS

Returns a number 1 - 5 if the applicant has listed the AFSC as one of his or her top 5 job preferences. Otherwise, a 9 is returned. To duplicate PACE, use ascending order to give volunteers first chance at the job.

Sort Code

Returns a number between 1 and 7 depending on the job Priority and if the recruit has picked the job as one his or her first 5 preferences. See AF Sort (PACE) for a full description of Sort Code.

Tech School Success

Technical School Success predicts how well (final school grade) a recruit will do in Tech Training School after BMT. The function is dependent on the recruit's four MAGE scores, AFQT score, high school graduation status, and 8 high school courses.

Tech School Success can be reproduced in GATES as:

AFQT * TechAFQT + MScore * TechMech + AScore * TechAdmin + GScore * TechGen + EScore * TechElec + HSGrad * TechHSGrad + (8 HS Courses * their associated weights)

Type Person

Returns the gender of the applicant. A 0 is returned if the applicant is female and 1 if the applicant is male. In actual PACE, GTEPs have a value of 0, females are 1, and males are 2. Since the model assigns GTEP recruits after the first step, only females and males are considered for the Type of Person.

In GATES, the function can be reproduced as:

Gender

Variable Fill

Variable Fill takes into account the ratio of jobs filled to jobs released. This function only has meaning for sequential algorithms where the ratio changes after every assignment. See Hendrix et al. (1979) for a complete description of this function.

Creating New Components and Functions

The User Payoff and LP algorithms provide an opportunity to define new components for use in payoff/objective functions. To create a new component, press the New button on the right side of the User Payoff or LP algorithm dialog box. After the Add Component dialog box appears, enter the name of the new component in the Component Name text box. Component names are case sensitive and mandatory. If a name is not entered, GATES deletes the old component or cancels the new component. Next, enter the expression of the component which can contain Field Names (described in the format files), arithmetic operators or existing components. Lastly, determine the weight of the component (the default weight is 1). These weights must be changed separately for each of the algorithms and Measures of Merit except for the Sort algorithm which does not use a weight. Note that pre-defined components such as TechSchoolSuccess only allow the user to edit the weight and will ignore any text in the Enter Expression text box.

Arithmetic Operators

The following are the allowed arithmetic operators:

+ Addition
- Subtraction
* Multiplication
/ Division
^ Exponentiation
(,) Parentheses

Example New Components

Fields must be used exactly as they appear in the Format Files. For example, to multiply the applicant's Mechanical Score by the AFS's Mechanical Weight in the Qualification file, enter "MScore * TechMech". Two additional fields are defined in GATES but not listed in the format files: AptAreaScore is a function that returns the applicant's aptitude score for the aptitude area for an AFS being considered for fill and AreaPref is a function that returns the applicant's integer preference for the aptitude area to which an AFS belongs.

A few examples for creating new components along with their resulting value are listed below.

Given:
Person1 with MScore = 60, AScore = 55, MPref = 2, and APref = 3
Job1 with PrimAptArea = 'M' and PrimAptMin = 47
Job2 with PrimAptArea = 'A' and PrimAptMin = 54

New Components and Results:
5 * (4 - 1) ^ 2 = 45
MScore + AScore = 115
AptAreaScore - PrimAptMin = 13 for Job1 and 1 for Job2
AreaPref / (MPref + APref) = 0.4 for Job1 and 0.6 for Job2
Max(AptAreaScore, PrimAptMin) = 60 for Job1 and 55 for Job2
Min(AptAreaScore, PrimAptMin) = 47 for Job1 and 54 for Job2

Editing Existing Components

To edit the weight or expression for an existing component, highlight the desired component and click the Edit button. For pre-defined components, only the weight may be altered, any text in the Enter Expression text box will be ignored. Follow the instructions in the previous section for creating a new component omitting the part about entering the component name. Remember that any changes to the expression for the component will be reflected for all algorithms and Measures of Merit.